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Vol.31 No.9

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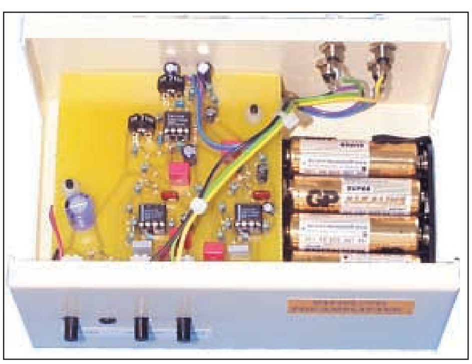

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PORTABLE TELEPHONE TESTER by Alan Paton — 648
A useful tool for testing those bargain boot sale phones before you buy!

EPE MORSE CODE READER by John Becker — 656
Multi-function Morse code translation and learning aid; standalone plus optional PC interface

VINYL TO CD PREAMPLIFIER by Terry de Vaux-Balbirnie — 665
Copy your old records to CD, and perhaps enhance their quality in the process!

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Our October 2002 issue will be published on Thursday, 12 September 2002. See page 627 for details

NEXT MONTH

FREE 16-PAGE SUPPLEMENT

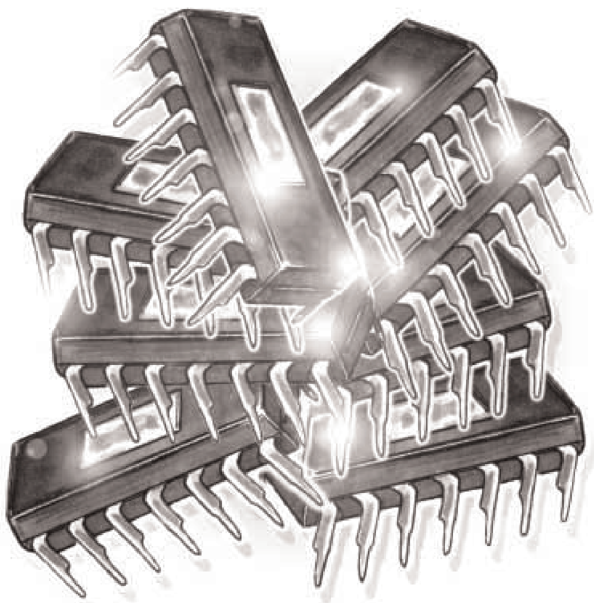
COLLECTING AND RESTORING VINTAGE RADIOS

Learn all about this fascinating aspect of electronics. It's a growing interest around the world.

DIGITAL I.C. TESTER

During project construction, many hobbyists must have wondered if the reason their masterpiece wasn't working was due to a faulty i.c., or if the i.c. they've just removed from an old board actually works. The project described here provides a simple way to quickly test the operation of most TTL and CMOS digital logic i.c.s.

A PIC16F877-20 microcontroller is used as the core of the circuit and is interfaced to a PC-compatible computer via an RS232 serial connection. Defined logic levels are applied to the inputs of the device under test and the results generated on the output pins are compared against those that are expected. The PC software has been written in Visual Basic 6 and should run on any Microsoft 32-bit operating system, including Windows 98, ME, NT, 2000 and XP. It is supplied with profiles for a selection of common TTL and CMOS devices and other device profiles can be added.



EPE BOUNTY METAL DETECTOR

An entirely new induction balance design providing an inexpensive, easy-to-build locator with a good depth of penetration. It will find a 25mm diameter coin at up to 240mm depth. Induction balance detectors can distinguish between ferrous and non-ferrous metals and this design is capable, to a large extent, of rejecting iron and also tin foil. The circuit uses just two i.c.s plus a couple of dozen other components.

PIC-POCKET BATTLESHIPS

The game of Battleships is normally played by two players with pencil and paper. Its aim is for each opponent to sink the other's fleet before their own is sunk. The variant of the game described here provides the excitement of the sea chase for just one player, who pits his wits against a PIC microcontroller as the other opponent. The position of the enemy (set by the PIC program!) is unknown and there are five merchant ships to be protected, whose positions are shown on a 5 x 7 l.e.d. matrix display.

Some ideas for PIC-progamming experts to enhance the basic game are discussed in the article.

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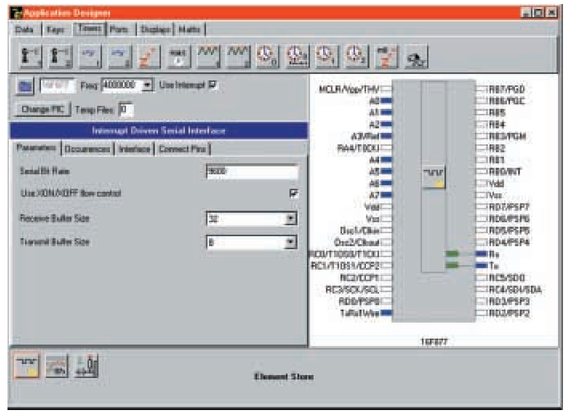
What is the WIZ-C Rapid Application Environment?



- Our PIC C compiler including a new front end
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- Drag a software component onto your design & set up the parameters using check boxes, drop down boxes and edit boxes (see shot right)
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- C Compiler designed to ANSI C Standards

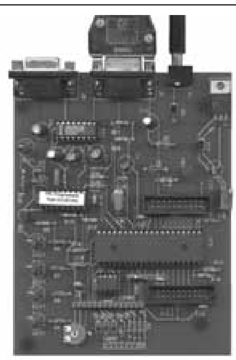
Professional Version Enhancements
to our C Compiler and WIZ-C Rapid Application Environment

- Manage and simulate multiple projects together
- Connect PIC pins across projects to allow simulated devices to communicate
- Handle assembler and C projects
- View and inspect variables in native C format
- Inspect all local variables and their values in native C format
- Maintain a history within simulation to back track and determine the past leading up to an event

Prices
WIZ – C Standard – **£70.00**, Professional **£100.00**. Upgrade for existing WIZ-C owners **£30.00**
PIC C Compiler Standard – **£60.00**, Professional **£90.00**. Upgrade for existing Compiler owners **£30.00**
Other upgrade options are available together with reduced price bundled packages – see our web site for details

Other products supporting 18F452 and 16F877

Development Board



- Handles 40 pin PIC devices including 18F452 and 16F877
- Includes on board Programmer – no separate programmer required
- 4 LED's on board, Analogue on trimpot, 2 duplex serial ports
- 1A 5V regulator
- 20MHz crystal
- Interfaces for LCD, hex keypad, 32 I/O pins on IDC connectors
- Will run FED PIC BASIC (included on CD)
- I2C EEPROM socket

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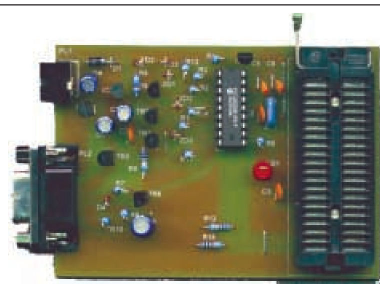

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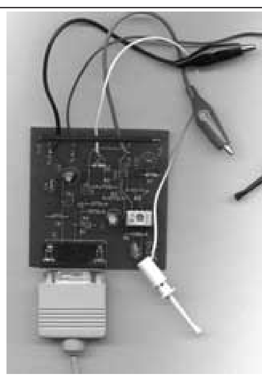

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MYSTERIES OF THE PAST

Next month we delve into the mysteries of the past. A hobby that has become established over the last decade is that of collecting old radios, communications equipment, test gear etc. There is now a well-established vintage radio trade in the UK and around the world, an interest catered for by our sister publication *Radio Bygones*, which is the leading British publication for vintage radio enthusiasts.

In a special 16-page supplement *Free* with next month's *EPE* we will take a look at what is available, what and how to buy, restoration and suppliers. It is fascinating to restore equipment from 50 years ago and then use it. Of course, all the old radios can still be used and most of the test equipment likewise. The technology is rather different from that of today so, for many readers, it will mean learning about valves, but, of course, these are still used by most of us everyday in the rather specialised form of the cathode ray tube, which was actually invented in 1859!

Whilst the technology is certainly very different, most of the parts are still readily available and many of them have changed very little over the last 50-odd years. What has changed is the style of cases etc., but a couple of manufacturers are now recreating radios in the style of 60s sets, namely Bush and Roberts Radio. So there must be something to be said for the designs of yesteryear.

EPE has published the occasional valve project, and a number of guitarists and hi-fi enthusiasts still believe the valve sound is the best. Certainly collecting and restoring valve hi-fi equipment is also booming in the UK.

NVCF

For anyone interested in old radios, communications equipment, record players, juke boxes, telephones, hi-fi etc., then a visit to the NEC on September 15th will be worthwhile. The *National Vintage Communications Fair* is held on that day and hundreds of companies take stands to sell everything from valves and components through vintage radios, TVs, telephones and hi-fi up to juke boxes and even telephone boxes. It is well worth a visit and *Radio Bygones* will be there selling back issues, books, data CD-ROMs etc.

If you are interested in this facet of electronics, then why not go along and see what it is all about.

Mike Kenward

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see below), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yebo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just $9.99(US – approx £7.70) per year available from **www.epemag.com**

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Constructional Project

FREEBIRD GLIDER CONTROL

MIKE BOYDEN

An automatic flight attitude control system suitable for free flight model gliders

IN order to amuse his young nephew last summer, the author made a number of model gliders, which were taken to the top of a local hill and then launched. The models were made from balsa wood and were not powered in any way, except by gravity.

Several designs showed some promise, but maintaining level flight with any consistency was a problem. Promising designs were shelved because after 20 metres they showed signs of losing stability, preferring to roll over or stall with the occasional "crump" of deforming balsa wood.

FLIGHT TIMES

As their glides were observed, it seemed apparent that it must be possible to incorporate an automated flight control system, to give the designs at least a fighting chance. Following a number of prototypes, this article describes how to make and install into a model glider a low cost microcontrolled stabilisation system that helps model gliders to fly a little more straight and level.

Glider flight times have been increased from an average of five to six seconds to over 15 seconds – the limitation now being that the author's local hill is just not big enough! The real power of Freebird is that the flight correction algorithm can be modified by reprogramming the PIC16F84A microcontroller, which handles the attitude detection and flight correction, all in real time.

FLIGHT PATH

To encourage budding aeronautical engineers (young and old) to take up this mid-summer madness, an overview of aircraft flight dynamics and some practical flying information has also been included. The design has been kept simple, using low cost and readily available components. For inexperienced model makers, a glider can be purchased.

During development, a portable computer was used in conjunction with the *EPE Toolkit Mk3* (Oct/Nov '01), to provide full "in-the-field" tuning of the software, but this is not essential.

FLIGHT THEORY

A full analysis of how aircraft fly is a complicated subject and cannot be fully detailed here. Further reading on the subject of aerodynamics is given at the end of this article.

In summary, for a fixed wing aircraft to fly, it must be made to move forward. The wings are designed to convert part of the falling motion into a forward motion. As the wings move forward they produce lift, which acts against the weight of the glider, effectively making it "lighter". The "lighter" glider in turn requires less forward speed so it settles into stable forward flight.

The forces acting on a glider in stable flight are shown in Fig.1. The main forces are:

- Lift force generated by the wings (upwards)
- Weight of the glider and control electronics (downwards)
- Drag or retardation force as the glider tries to move through the air (backwards)
- Propulsive force which for gliders is supplied by gravity (forwards).

In stable flight, the lift force is just less than the weight force, (i.e. the model slowly descends) and the thrust force is greater than the drag force (i.e. the model moves slowly forward).

The objective of glider designers is to maximise the distance moved forward by the glider and minimise the vertical distance it falls. This is known as the optimal glide-slope (refer to Fig.2) and Freebird is aiming to keep the glider within these operating parameters at all times.

Incidentally, this is also a guide to the slope of a good hill to launch from, as the glider should be able to continually "fall", yet maintain a constant height from the ground.

So by the addition of wings, the simple falling object is turned into a gliding object. The next problem to solve is how to control the motion of the aircraft in three-dimensional space.

FLIGHT CONTROL

Aircraft travelling in space can move in the following ways (see Fig.3.):

- Pitch – a rotation about an axis that passes through the wings – looks like a raising or lowering of the nose. To correct alterations in pitch, the elevators located on the tail surfaces are adjusted in unison (i.e. both elevators up or both down).
- Roll – a rotation through the centre line of the fuselage – looks like one wing rises, whilst the other falls. To correct alterations in roll, the ailerons located on the wings are adjusted in opposition (i.e. one aileron moves up, whilst the other moves down).
- Yaw – a rotation about an axis perpendicular to the fuselage. To correct alterations in yaw, the rudder located on the tail is adjusted.

When in flight, all sorts of forces act on the aircraft, so that at a given instant any combination of these motions may be evident – it really is a wonder that a hand thrown model glider flies any distance at all! So, the idea behind Freebird is to correct these motions before they become too extreme and result in the aircraft crashing.

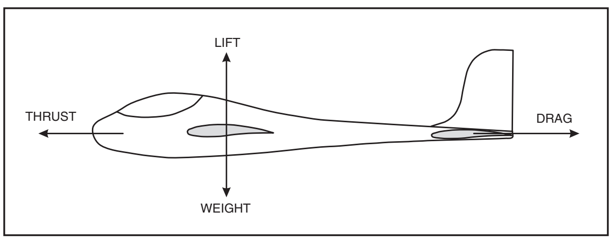


Fig.1. Forces acting on a glider in stable flight.

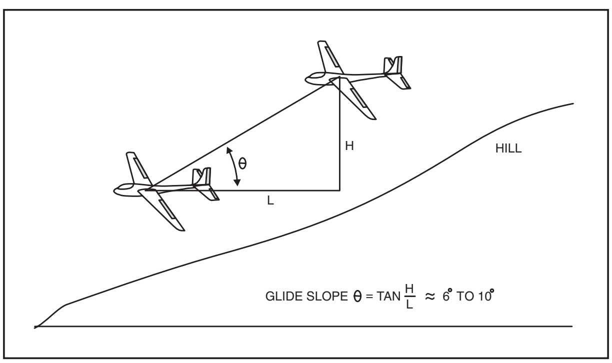


Fig.2. Optimum glide-slope. Objective is to maximise distance moved forward and minimise the vertical distance it falls.

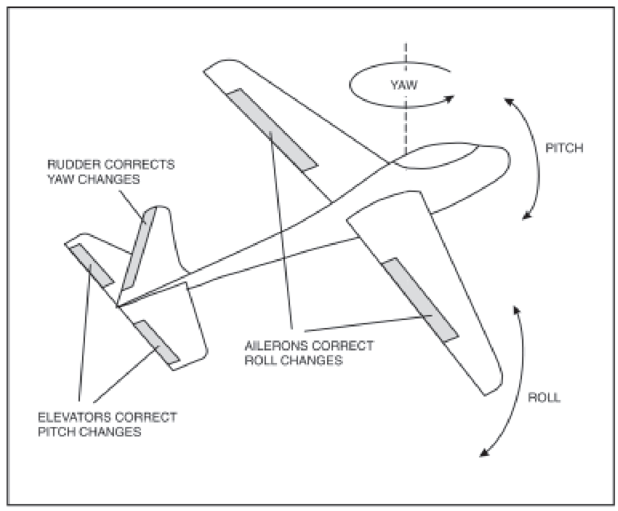


Fig.3. Aircraft attitude and surfaces used to control movement. These help stabilise against the forces of pitch, roll and yaw.

FREEBIRD DESIGN

The design for Freebird was loosely based upon commercial aircraft autopilot systems. Auto-pilots allow pilots to relax by flying the aircraft without any human intervention and are normally used in the mid-section of long flights where airspace is not crowded and there is less need for the aircrew to laboriously maintain a fixed heading and level flight.

Any autopilot requires the following systems to be present:

- An attitude detection system.
- A computational system that detects attitude alterations and determines the correction necessary to restore normal flight.
- A servo system, that can move aircraft control surfaces as directed by the attitude computer.

Usually, computations are based upon "generic" information that forms the basis of an in-flight mathematical model for that particular type of aircraft. Also, specific information is added that relates to that flight i.e. aircraft weight and local weather conditions.

Freebird does not carry out any mathematical computations, but outputs a predefined value of servo correction from look-up tables. Commercial detection systems make use of sophisticated detectors, including detectors sensitive to acceleration, which results in more refined control.

Although Freebird does not offer the sophistication of commercial systems, it does incorporate all of the elements detailed above.

CIRCUIT DESCRIPTION

The complete circuit diagram for Freebird is shown in Fig.4. The heart of the system is the PIC16F84A microcontroller, running at 20MHz, as set by crystal X1. Tilt switches sense changes in pitch (S1, S2) and roll (S3, S4). They are arranged in the same plane, but offset with each other at 90 degrees (see Fig.5).

When perfectly level, the switches are arranged to be off, which gives a degree of "dead band" and helps to reduce the sensitivity of the detection system. There is no sensor present to detect yaw and the correction for this motion is derived from the measurements taken from the pitch and roll sensors.

To assist the setting up procedure, light emitting diodes (l.e.d.s), D1 to D4, are included in series with the tilt switch, and are turned on when the respective switch closes. This corresponds to about 10 degrees of tilt.

Switches S5 to S8 are slide switches within a 4-way dual-in-line (d.i.l.) module. They allow different software routines or modes to be selected, as discussed presently, thereby altering the correction characteristics of Freebird.

The software can be changed without the removal of the PIC from the unit, by means of "in-circuit" programming socket, SK1. Note that this does not correspond to the pin arrangements used by John Becker in his numerous *EPE* projects.

FEEDBACK COMPUTATION

The software assembly listing contains a full description of the PIC's program operation and other details, so just a short summary is given here. The PIC undertakes the following tasks:

1. Reads the mode switch and executes the appropriate software module
2. Detects pitch or roll tilt, by means of the tilt switches (active low)
3. Determines the appropriate servo(s) to move and by how much
4. Determines if yaw correction is required based upon roll and pitch

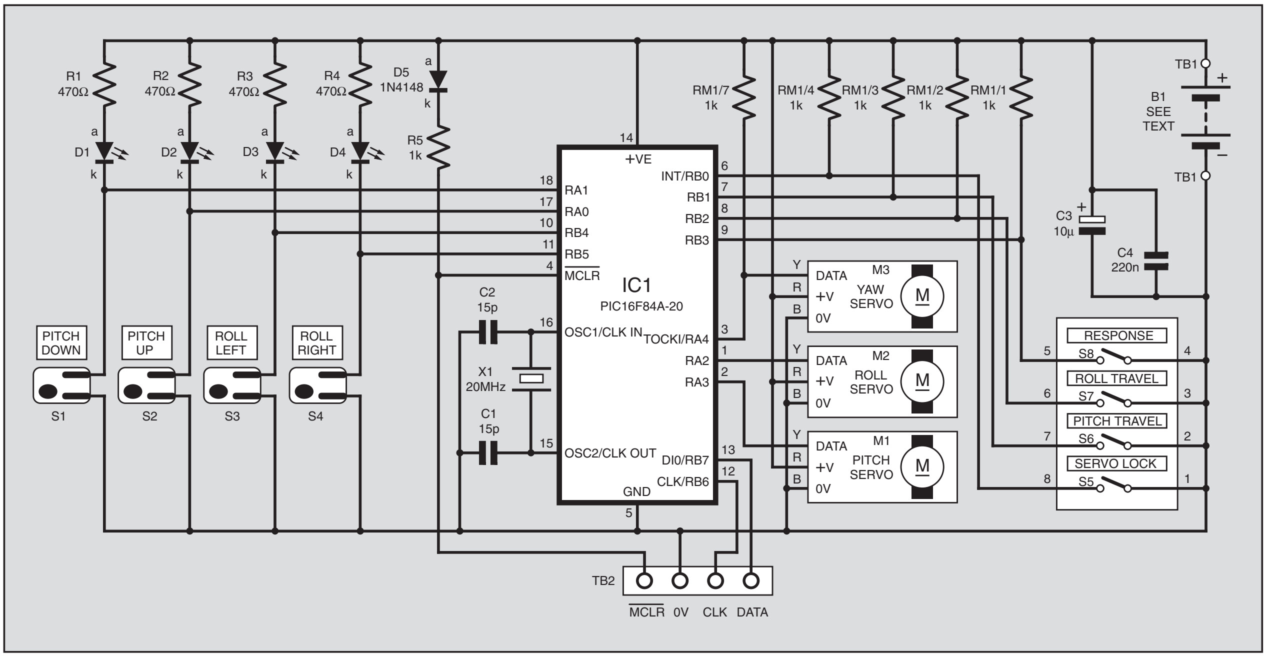


Fig.4. Complete circuit diagram for the Freebird Glider Control.

5. Outputs corrective commands to the roll, pitch and yaw servos

The main activities are carried out in (1) to (4) and are arranged to loop endlessly. The servo output module is called by a timer interrupt every 18ms and this ensures that the servos receive their control information, irrespective of other activities going on at the time.

The main loop senses which, if any, of the tilt switches are active. The combination of tilt switch closures is used to enter look-up tables which define the appropriate degree of servo correction necessary. These values are placed into servo position register stores in readiness for output when the servo interrupt is executed.

The following modes are available in the software, and are selected by switches S5 to S8:

S5	S6	S7	S8
Servo Lock	Servo Travel Pitch	Servo Travel Roll	Response
On enabled	full	full	fast
Off disabled	half	half	slow

Servo Lock, switch S5: When enabled, all servos are locked in their current positions. This helps with alignment (say, checking zero, maximum up or down elevator deflection on the aircraft). It also allows the initial checking of l.e.d.s to be carried out in comparative quiet without the servos moving.

Servo Travel Pitch, switch S6: the travel of the pitch servo can be increased or decreased. When enabled, the servo rotation is ±60 degrees. When disabled the travel in each direction is halved, i.e. about ±30 degrees.

Servo Travel Roll, switch S7: as Pitch switch S6, but with respect to the roll servo.

Response, switch S8: when enabled (slow), the rate of travel of the servo movement is approximately one second from +60 degrees to 0 degrees. This sluggish response is better for flying on still, hot summer days, or with larger gliders. When disabled (fast), the movement is speeded up to 0·5 seconds. This setting is useful in gusty conditions where the glider must respond rapidly in order to maintain stability.

Any mixture of the above functions can be selected.

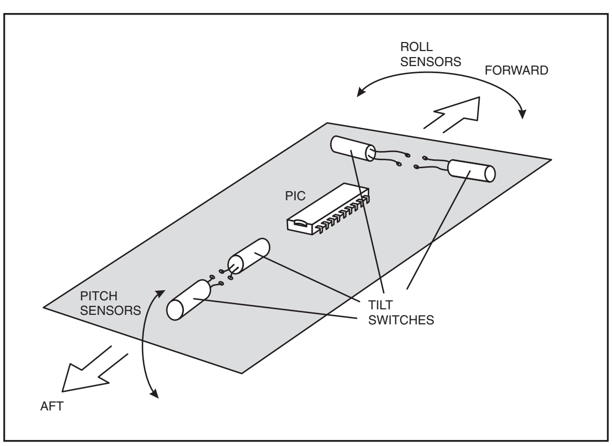


Fig.5. Attitude detection using tilt switches. Pitch S1/S2 and roll S3/S4 are arranged in the same plane, but offset at 90° from each group

COMPONENTS

Resistors

R1 to R4	470Ω (4 off)	
R5	1k	
RM1	1k 8-way commoned s.i.l. resistor module	

See SHOP TALK page

All except RM1 0·25W 5% carbon film or better.

Capacitors

C1, C2	15p (or 10p) ceramic (2 off)
C3	10µ radial elect. 16V
C4	220n ceramic

Semiconductors

D1, D4	sub-min green l.e.d. (2 off)
D2, D3	sub-min red l.e.d. (2 off)
D5	1N4148 signal diode
IC1	PIC16F84A-20 preprogrammed microcontroller (see text)

Miscellaneous

M1 to M3	Servo motor (see text) (3 off)
S1 to S4	Tilt switch (non-mercury type) (4 off)
S5 to S8	4-way d.i.l. on-off slide switch module
TB1	2-way pin connector, male, or 1mm terminal pins
TB2	4-way pin connector, male, or 1mm terminal pins
X1	20MHz crystal

Printed circuit board, available from the *EPE PCB Service,* code 367; battery pack (see text); connecting wire; solder etc.

Approx. Cost Guidance Only **£15** ***excl. servos & batts.***

POWER SUPPLY

A supply of between about 5V and 6V is required to power the PIC and servos. Power consumption peaks at around 430mA with all three servos in motion, but normal steady state consumption is around 45mA. To keep costs down, dry cells can be used although rechargeable cells such as Nickel Cadmium do help to reduce costs in the long run.

The most important consideration here is weight. Use of four AA-size batteries is acceptable, weighing about 170 grams, and supplying about 1·5V each (total 6V). The balance of the glider is important and the battery pack will play an important part in the eventual setting up.

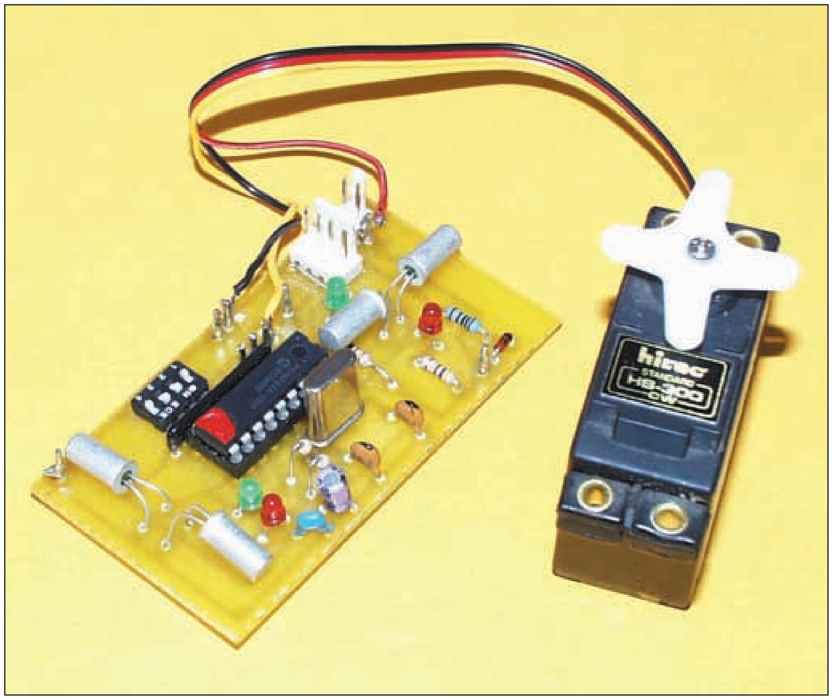
SERVOS

Model radio control servos are used to control the aircraft as these are purpose built, lightweight, available at modest prices and are designed to be installed into model aircraft. Radio control servos require a position instruction every 18ms and the PIC's interrupt routine is set to output this information, irrespective of what other tasks are being executed. The servo position instruction comprises a 1ms start pulse followed by a command pulse varying between zero and 1ms.

The servos are 3-wire units. The positive lead connects to the power supply positive line, the earth connects to battery negative, and the data line to the appropriate PIC output.

An analysis was not considered necessary with regard to the vulnerability of each system to the overall stability (and therefore safety) of the control system as it would be used in a hobbyist setting and not for commercial use.

However, an airbrake could be added should the glider remain airborne for too long. Readers knowledgeable in PIC program writing could easily modify the software to drive another servo to control it. A timer of up to 14 minutes duration could be created by counting the 18ms interrupts by means of a 16-bit counter.



Completed printed circuit board connected to a single servo motor. Note the four attitude tilt switches.

CONSTRUCTION

The printed circuit board (p.c.b.) assembly and track layout details are shown in Fig.6. This board is available from the *EPE PCB Service*, code 367. Assemble in your own preferred order, noting the direction of the diodes and capacitor C3. Use a socket for the PIC.

Identify the common lead (it has a spot alongside) on the s.i.l. resistor module and position it as shown. Note that p.c.b. holes have not been provided for the unused resistors in the module. The unrequired leads should be folded back to allow the module to slot into the p.c.b.

Install the tilt switches with plenty of curvature in the leads – this will make later adjustments easier.

Make sure the d.i.l. switch is soldered in correctly (i.e. the switch should be closed when at the top of the bank, and off at the bottom).

After you have fully checked the correctness of your soldering and assembly, and confirmed that the power supply is correctly working, insert the preprogrammed PIC into its socket, ensuring its correct orientation. If you have your own PIC programming facility, such as the *EPE Toolkit MK3/TK3* programmer, the PIC could be programmed *in situ*. See this month's *Shoptalk* page for details of obtaining the software and preprogrammed PICs.

Note that the programming pinouts of the TB1 connector do not correspond to the "standard" John Becker arrangement.

Do not connect the servos to the p.c.b. until after the following initial setting up.

SETTING UP

Place the assembled p.c.b. on a flat table and ensure that switch S5 (Servo Lock) is selected to *disabled* (i.e. all servos unlocked). Physically adjust the vertical angle of the tilt switches until all the l.e.d.s are just out. Raise the free end of the bent over tilt switch to turn it on earlier, lower to turn it off later.

To check the Pitch setting, raise the rear of the board by approximately 10mm until tilt switch S1 and l.e.d. D1 just turn on. Return

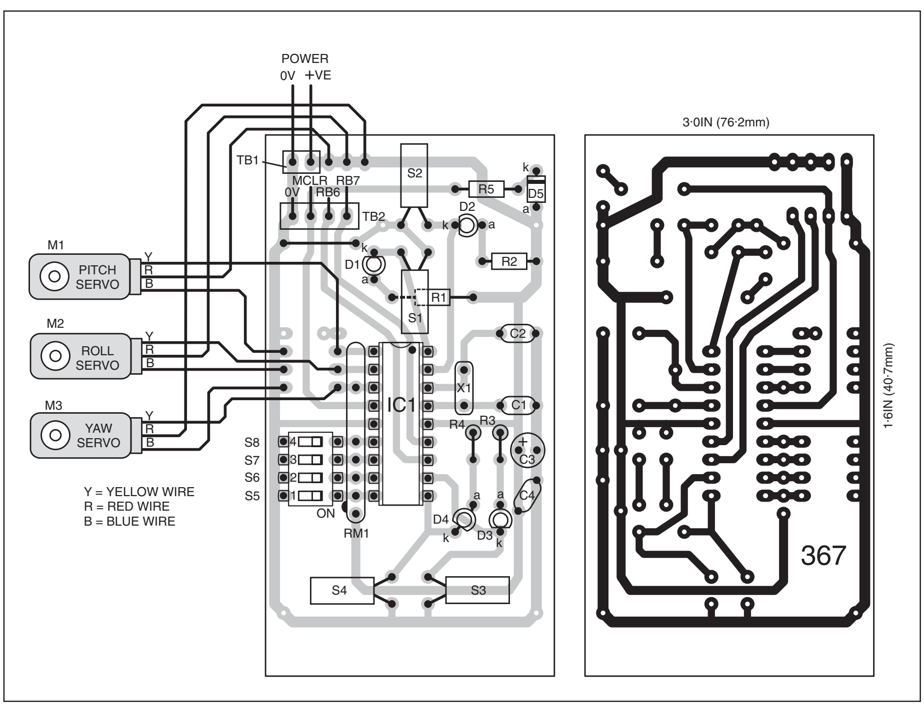


Fig.6. Freebird printed circuit board component layout, wiring details to servo motors and full-size copper foil underside master pattern.

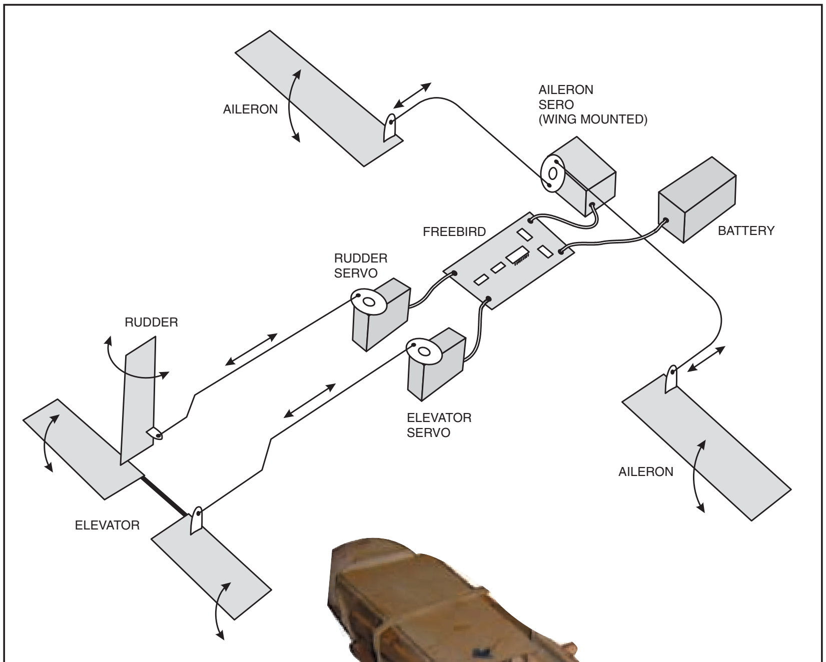


Fig.7. General arrangement of servos within the glider.

the board to horizontal and then raise its front by about 10mm, to check switch S2 and l.e.d. D2.

To check the Roll setting, lift the left edge of the board (i.e. bank to the right) and check tilt switch S4 until l.e.d. D4 just lights. Repeat for left banking.

Connect up the yaw servo. Check that this servo responds to right and left roll. Then connect up the Pitch and Roll servos (omit the roll servo if desired – see later). Mark each servo with labels stating "Elevator" (pitch, RA2), "Aileron" (roll, RA3) and "Rudder" (yaw, RA4). Check that all of the mode slide switches (S5 to S8) operate correctly.

Freebird is now ready for installation into a glider.

WINGS AND THINGS

More experienced model makers may wish to build their own glider specifically for the job. For those new to flying "free flight" model gliders, purchasing a partially completed model is recommended, which only requires minor additions for completion.

For the novice, the subject of model gliders and how to fly them is quite extensive, but with a little patience, an enquiring mind and a will to "tinker", there is no reason why a reasonably good glider, with adequate flight characteristics cannot be built. Joining a club will be of great benefit to the novice.

With the prototype installation, using a NiCad battery pack and three servos, the weights were as follows:

Battery pack	150gms
Freebird p.c.b.	30gms
Servos	150gms (total)

Adding a little for linkages, nuts and bolts, the total payload weight was about 350gms. The servos used for initial tests were far heavier than necessary and were later replaced with "micro servos", reducing the weight by 80gms.

The glider requires to not only lift itself, but also the payload, plus a little for luck. It all gets a little complicated now and you are best advised to ask your local model hobby store to recommend a glider. Tell them you need something suitable for a novice to build, the payload will be 350gms, with a low wing loading.

For good stability, look to acquire a glider with a "double dihedral" wing.

Fix the wings to the fuselage using several large overlapping rubber bands. This helps to absorb the shock when landing on a wing, which is a common event, although it is reduced as Freebird becomes more "tuned".

ON BALANCE

The model must balance correctly in the pitch and roll axes. The balance point for pitch should be one-quarter to one-third of the width of the wing back from the leading edge. Position batteries or a dummy weight to obtain this balance point.

Check that the model balances also in the roll axis, by supporting each end of the fuselage centre line with pins. Check to see which direction the glider rolls. Use PVC tape or some coats of dope (model paint) on one wing as counterweights to correct as much as possible, although perfect balance in this axis is not really possible.

Note that Freebird is not sophisticated enough to enable a poorly constructed and set-up glider to fly, but it will extend the flight of a reasonably well set-up glider.

When selecting a glider, remember to check that the wings are detachable and that all the various parts will go through a car door. Access to the p.c.b. will be necessary to allow different software modules to be selected via the d.i.l. switch. This normally will require the wings to be taken off. If you intend to carry out "in the field" programming, check that a small hole can be made in the fuselage for the programming connector.

The first objective should be to obtain a good understanding of a free flight glider by making a series of flights with the glider loaded up with equivalent weight of batteries and servos. Learn how to note the weather conditions, how to check the balance, and how to launch.

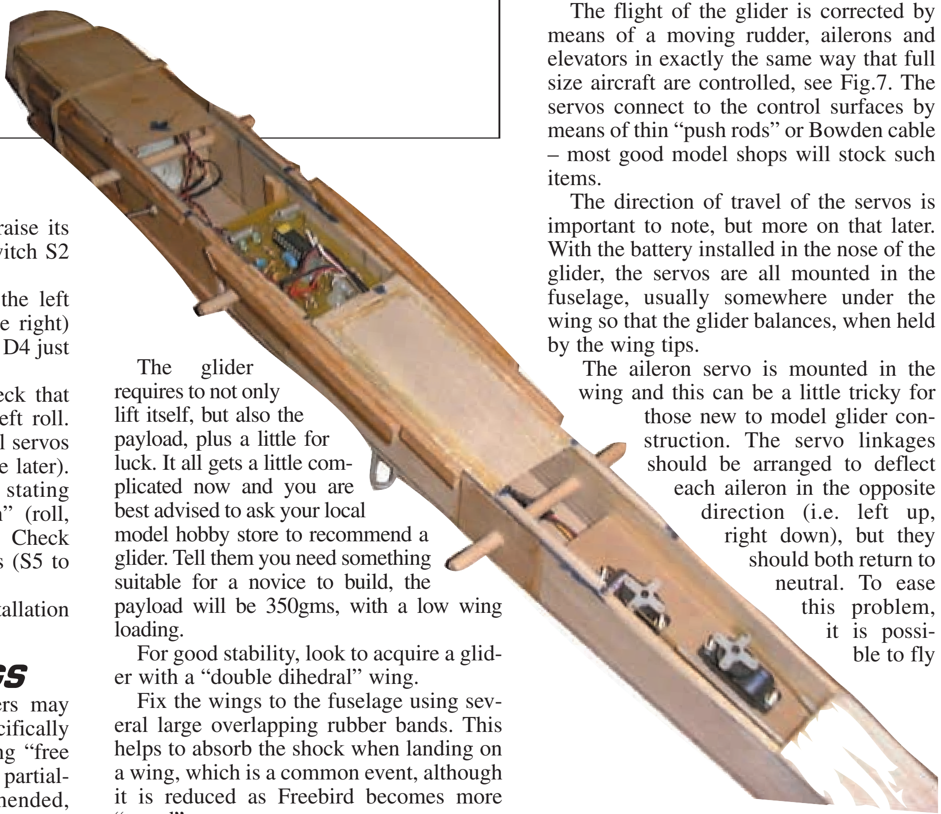
Finally, learn how to note each flight and the correction(s) (make only one at a time) necessary to slowly improve the flight time. Breakages and how to fix them on the hills will become second nature!

INSTALLATION

The flight of the glider is corrected by means of a moving rudder, ailerons and elevators in exactly the same way that full size aircraft are controlled, see Fig.7. The servos connect to the control surfaces by means of thin "push rods" or Bowden cable – most good model shops will stock such items.

The direction of travel of the servos is important to note, but more on that later. With the battery installed in the nose of the glider, the servos are all mounted in the fuselage, usually somewhere under the wing so that the glider balances, when held by the wing tips.

The aileron servo is mounted in the wing and this can be a little tricky for those new to model glider construction. The servo linkages should be arranged to deflect each aileron in the opposite direction (i.e. left up, right down), but they should both return to neutral. To ease this problem, it is possible to fly Freebird using only two servos (elevator and rudder) although correction of roll is not as effective.



Positioning of the circuit board, servos and battery (nose cone) in the fuselage sections.

Each control surface will require a different degree of movement to adjust the flight of the glider, but a surprisingly small change can have a significant effect. Normally, the control surface needs to only move about 10 degrees above or below the horizontal to have an effect on flight attitude.

The surface area of the control and the speed of flight also have an impact upon the amount of travel necessary. Make use of the servo lock mode to view the travel distances and check the neutral point of each surface is exactly in the centre of travel. Add small offsets in the lookup tables to correct minor errors, or adjust the travel at

the servo arm. Also, most servo arms can be removed and repositioned to extend the range of convenient positions.

SERVO TRAVEL

Note the direction of travel of each servo and check that the movement will alter the control surface in the correct direction. If the direction of travel is incorrect, swap to the other side of the servo control arm, or rotate the servo 180 degrees in the aircraft, or change the linkage to the control surface. Ensure that all of the movements are correct, before installing the servos, as making changes after installation in the glider is difficult and time wasting.

Ensure that some adjustment can be made to the servo travel (normally done with a small brass threaded screw connected to the servo drive disc, again available from model shops). If a PIC programmer is available then simply adjust the zero point in the "look-up" table.

Position the battery unit into the front of the glider. The glider should balance when held by the wing one-third of the way from the leading edge – check this and adjust the battery pack as necessary. Locate the battery pack with balsa wood and sponge to act as a shock absorber.

Connect up push rods or cables to the control surfaces. Install the p.c.b. (tilt switch S2 points aft (tail)) in the fuselage, under the wings and on the floor of the glider. Check that access to the programming socket is clear. Check that with the wings level and the fuselage level all l.e.d.s are off – readjust as necessary. If the servos are moving all the time, then they can be locked using slide switch S5.

Locate and bolt the p.c.b. into the glider and use a hot-melt gun to finally fix the tilt switches onto the PCB. It may be necessary to hot-glue any connectors, as the author has sometimes found them disconnected after forceful landings.

SOFTWARE TECHNICALITIES

The software is written with simplicity and the expectation is that it will prompt experimentation, modification and improvement.

The core of the software is centred around the PIC TMR0 timer. This is set to interrupt the mainline every 13ms thus ensuring that the servos are serviced with their control pulses irrespective of the other things going on. The interrupt code outputs to each servo a 1ms start pulse followed a command pulse of between 1ms and 2ms duration.

When the program is not executing an interrupt, it is constrained to constantly execute the mainline loop. The mainline undertakes three tasks:

1. read mode switches and execute the appropriate software module
2. read tilt switches
3. calculate required position of all servos and load the demand variable, in readiness for the interrupt to output it.

Three variables define servo demand:

servop – pitch servo position

servor – roll servo position

servoy – yaw servo position

Flight correction table for Pitch:

Flight Attitude	Sensor values D1	U1	corrective servop value	elevator degrees
Level flight	1	1	125	0
10 deg pitch down	1	0	187	10 up elevator
10 deg pitch up	0	1	62	5 down elevator
Inverted flight	0	0	n/a	n/a

Flight correction table for Roll:

Flight Attitude	Sensor Values L1	R1	Corrective servop value	Aileron degrees
Level flight	1	1	125	0
10° roll left	1	0	187	5 right aileron
10° roll right	0	1	62	–5 left aileron
Inverted flight	0	0	n/a	0 n/a

Flight correction table for Yaw:

Flight Attitude	Sensor Values L1	D1	R1	U1	Corrective servoy value	Rudder degrees
level flight	1	1	1	1	125	0 centre
10° roll left, only	0	1	1	1	187	15 right
10° roll right, only	1	1	0	1	62	–15 left
10° roll left, pitch down	0	0	1	1	250	30 right
10° roll right, pitch down	1	0	0	1	0	–30 left
10° roll left, pitch up	0	1	1	0	187	15 right
10° roll right, pitch up	1	1	0	0	12	–15 left
Inverted flight	0	0	0	0	125	0 centre
Error	1	1	0	0	125	0
Error	0	0	1	1	125	0

A servo position is determined by the value placed in any of the variables above. Five positions for the pitch servo are given below. The current servo position is held in the variable **servpc** and is used where a slower rate of movement has been selected.

Servop (decimal)	Servo degrees
0	–30
65	–15
125	0
187	+15
250	+30

The rate of travel of the servos can be adjusted by means of the mode switch. The demand position is subtracted from the current position to give an error value and the servo is instructed to move in the direction so as to reduce the error to zero.

Freebird can operate a fourth (auxiliary) servo. This could be used to operate air brakes, after a period of time for example. As said earlier, one way to devise a timer could be to use the 18ms interrupt to increment a 16-bit counter. This would give timed periods in excess of 15 minutes.

It is possible for Freebird to detect inverted flight, but correction of this extreme situation has not been implemented.

New and experimental code can be programmed into the PIC either at home, or on the hillside and then tried out. The mode switches can be reprogrammed for this task if required.

The attitude sensors are defined as:

Pitch:
U1 forward sensor (senses 10° pitch up)
D1 aft sensor (senses 10° pitch down)

Roll:
L1 right sensor (senses 10° roll left)
R1 left sensor (senses 10° roll right)

Yaw:
not present (computed response)

FLYING

Take care when selecting the launch site. Avoid crowded areas and places where the glider might stray into traffic. Make sure that access to the site has been approved and preferably fly with a club. The following list of equipment that can be put into a rucksack may be useful for the independent flyer.

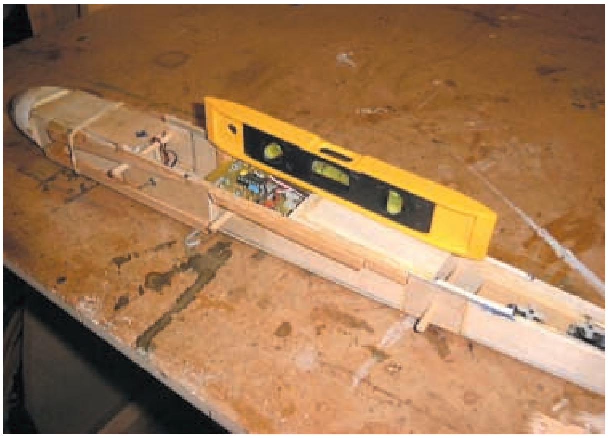
Notepad and pen
Small selection of Balsa and glue
Tissue paper, dope, cleaner and brush (for covering holes in the tissue covering)
Selection of trimming weights (nuts and bolts)
Spare set of batteries
Pliers, screwdriver
Rubber-bands
PVC Duct Tape
Sunglasses, blanket, sandwiches, flask of coffee!

Choose a sight with a 180 degree unobstructed field of view (i.e. no trees, styles or fences etc) combined with a good slope of about 30 or 40 per cent. For initial glide testing, try to find a field with long grass – this makes a good cushion.

For the first flight, unlock the servos and set pitch and roll to maximum travel and response rate to fast. Tilt the glider and check that each control surface moves in the correct direction. Recheck the glider balance, under the wing tips.

Launch the glider into wind whenever possible. Try to avoid gusty conditions at first. Do not launch the glider upwards – this will result in a stall. What the glider initially requires is airspeed, so launch the glider horizontally. It will initially drop quickly until airspeed is gained and then it will then slow down and settle into stable flight.

As soon as possible note what the glider does. If it pitches up and stalls, set a little more down elevator. Take your time in between flights – think about what happened. Trace the flight path with your hand to reinforce the complexities in your mind



Using a spirit level to check fuselage "balance".

Using several coats of dope (model paint) to counter-balance wings.

– what needs to be corrected? It can be several motions combined – try correcting one motion or problem at a time. Check the balance every time the glider is prepared for a launch.

FLIGHT PLAN

Note that flying gliders that have pronounced flight duration requires fliers to give extra consideration to safety. Keep models to a wing span of less then 90cm. Avoid flying near roads where car drivers might be distracted or in crowded parks. If you find a field, gain permission from the farmer or owner – these are small considerations and adhering to them will enable gliders to be enjoyed by everyone.

Try to join your local model flying club, where you will find a wealth of experience and talented people, added to the fact you should be covered by a club flying insurance policy. **Under no circumstances should Freebird be used in power models of any sort**.

Be aware that bad landings and various forms of breakages are a natural part of experimenting with free flying models and these should be seen as an inevitable part of investigating flying machines, rather than a major catastrophe. Patch them up and get them back into the air.

If you think that seeing your model with a broken wing on the first flight might tempt you to jump off the hill in despair, then this pastime is not for you.

The best of luck to those of you that might be tempted to build Freebird and venture out onto the hills this summer. □

References

Basic Aeronautics for Modellers, Alasdair Sutherland, Traplet Publications ISBN 0 9510589 4 0

Designing Model Aircraft, Peter Miller, Traplet Publications ISBN 0 9510589 6 7

British Model Flying Association: **www.BMFA.com** – all sorts of information about clubs etc.

Radio Controlled Soaring: **www.Rcsoaring.com** – gliders, gear, events.

Traplet Publications: **www.Traplet.com** – *Quiet Flight* gliding and electric flight magazines, designing and building aircraft.

News . . .

A roundup of the latest Everyday News from the world of electronics

SQUEEZING THE VIEWER

Barry Fox reports on how many World Cup fans felt squeezed out of the picture.

SCREEN Digest estimates that one in three large screen TV sets now bought in major European markets has a 16:9 widescreen. Dealers who saw the World Cup as a nice way to sell more sets were shocked to find the broadcasts were in 4:3 only. So were viewers who expected to see the full spread of the pitch.

Some fans were seeing short fat players because widescreen sets will often automatically stretch ordinary 4:3 pictures to fill a 16:9 screen. The broadcasters are still passing the buck and say only that they hope for better pictures next time in 2006.

The Dixons group had to pull a page from its web site which promised customers they would "see more of the world cup action on a widescreen television". "Mercifully," says a spokeswoman, "we hadn't put out a press release". Said a spokeswoman for the commercial ITV network: "We've had lots of calls from viewers wanting widescreen. It's a shame. It's a pity. But that's the way it is. We wanted to show the matches in widescreen but there's only one feed. And it's the same for ITV and the BBC".

Offside Passing?

The BBC had a prepared statement which claimed only 4:3 pictures are available from the satellite links, and blamed FIFA. FIFA pointed the finger at Host Broadcast Services, the Swiss-based company formed in 1999 to send World Cup pictures round the world. "It is not correct to say that the format of the TV production of FIFA WC 2002 is only 4:3", assured Francis Tellier, CEO of HBS "although it is correct to say that this is the format of the main HBS production. The choice to broadcast 4:3, not 16:9, has been made by the broadcast partners, not FIFA or HBS".

HBS was using two completely separate camera teams. One was shooting all 64 matches with 4:3 pictures, in the 525 line NTSC format used for everyday broadcasting in Japan and Korea; the other camera crews were covering only 48 matches and using widescreen cameras in the 1125 line high definition system used for some satellite services in the Far East. Although it is technically possible to convert the 1125 line pictures to 525 line NTSC, and to 625 line PAL for Europe and Australia, no country in the world was doing this.

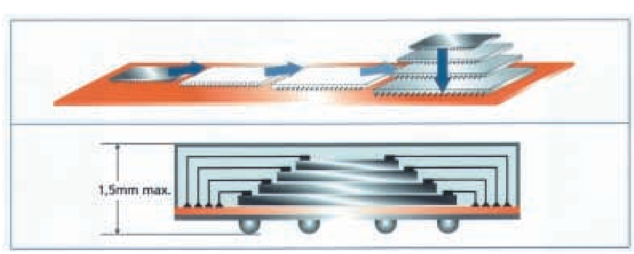
Out of Touch

The two camera teams were working completely separately so the pictures and views they provided were quite different and needed different commentaries. Also the widescreen pictures were not being shot with "protection" to ensure that vital action across the pitch is kept in the middle of the widescreen pictures. So a vital kick at the side of a 16:9 screen would have been lost off the edges of an ordinary 4:3 TV set.

Moreover, the widescreen teams did not have the exotic slow motion equipment used for instant replay on the 4:3 feeds. Also, it costs local broadcasters more to bring in both sets of pictures by satellite and give viewers a choice. As a result only Japan and Korea bought the widescreen feed.

Engineers inside the BBC have privately admitted to inadequate forward planning and accept they should do better next time. Pressure from viewers will count. Francis Tellier says HBS will re-think its policy for FIFA WC 2006 Germany "in light of the opinion of our broadcasters".

CHIP STACKING



NOT content with miniaturising the features that fill a given chip area, Sharp have taken the idea vertically as well as horizontally. Their latest development effectively stacks four chips on top of each other, all in the same package.

Sharp point out that "integration in the third dimension", i.e. vertically, offers substantial technical advantages: various chips from different production processes can be combined to provide a system solution within one casing, without having to change the shape factor.

For more information browse **www.sharpsme.com**.

Meterman's Offer

TO QUOTE their press release, "Meterman digital multimeters and test tools were designed for use in design, evaluation, installation, production, service and troubleshooting of electronic and electrical equipment and systems."

Meterman are currently offering a money-saving compact kit for electronic technicians and engineers for a limited period. Comprising a Meterman Digital Multimeter/Component Tester and a 4-way screwdriver, the two products provide a convenient troubleshooting kit for many electronic applications (what, no hammer?!).

The 27XT-P meter/tester offers 11 functions, a 2000 count, data hold/max hold and auto power-off features, fused current input and 0·5% basic accuracy. With category II safety compliance, it measures a.c./d.c. voltage and current, frequency, capacitance and inductance, resistance, continuity, and has a diode test facility. It also tests for TTL or CMOS logic. The heavy-duty screwdriver has 2 × Philips and 2 × flat-headed removable bits. The kit is available at the special price of £72 until the end of November this year. For more information about the full range of Meterman test tools and where they can be purchased, visit **www.Meterman.co.uk**, email: info@metermantesttools.com.

FML Bargains List

WHEN looking for bargain components, don't forget to include FML Electronics on your list – we've just received their latest double-sided sheet of bargain offers, covering batteries through to transformers, and they obviously have many competitive prices. Their 2003 catalogue is said to be "available shortly" and you only need to send an s.a.e. if you want a copy.

For more information contact FML Electronics, Dept. EPE, The Business Centre, Bridge Street, Bedale, N.Yorks DL8 2AD. Tel: 01677 425840.

Email: bargains.fml@breathemail.net.

MICROCHIP CD-ROM

MICROCHIP Technology, manufacturers of the PIC microcontrollers that we feature so frequently in our constructional designs, have released their Technical Library CD-ROM 2002. It comprises two CDs that feature a snapshot of Microchip's newly designed website and are viewable with an HTML browser.

Disk one itemises data for the full Microchip product range, disk two contains the full-line of Microchip's application notes and related source code, development tools and utilities.

EPE gave away the 2001 set of Microchip CDs as a front cover free gift with the October 2001 issue. However, even if you already have that information, it is still worthwhile asking Microchip for their latest CD set.

For more information on obtaining this CD-ROM set, browse **www.microchip.com**.

GAME ON AT THE BARBICAN

By Barry Fox

YOU have until September 15th to get on down to the Barbican Gallery in London and – provided you can find your way to, from and around the appallingly badly signposted Barbican area maze – enjoy *Game On: The Culture and History of Video Games*. Admission is £11, Concessions £8, Children 5-15 years £5, Under fives free.

The organisers advise advance booking, with timed tickets; it is easy to see why. They have brought together an astonishing collection of original games hardware and are giving visitors the chance to play on it. In all there are 150 arcade and home game consoles, and although gamers are asked to limit play to 15 minutes, the whole point of the exhibition will be lost if visitor numbers are not restricted.

It's hard to believe that computer game history dawned only forty years ago, when Steve Russell at MIT used paper tape to make a DEC PDP-1 play *Spacewar*. The real revolution began in 1971 with arcade games *Computer Space* and Atari's *Pong*. The first home console, the Philips' *Magnavox Odyssey*, went on sale in 1972. *Space Invaders* arrived in 1978 and *Pac-man* in 1980, followed by a deluge of old favourites from Atari, Sinclair, Commodore, Nintendo and Sega, with *Donkey Kong* and *Sonic the Hedgehog*.

All are up and running at the Barbican, some with original consoles, sometimes with ruggedised controls, and a few on large screen projectors. There's a look at the violence of *Grand Theft Audio* and the theory behind strategy games like *Sim City*. Sections on sound, storyboard scripting and hand-held portables lead on to a look at the future with *Liquid Fire*, a game that uses motion sensors to track a player's hand and body movements.

The organisers are going to have their work cut out keeping all the hardware working, but most visitors seem to be treating the equipment with reverence. Even people (like me) who cannot get excited about video and computer games, this is a superb exhibition. And it reminded me of an oddity which I must now try and unearth from my attic; a very early hand-held tennis game from Japan that used a clockwork drive to flip little lights on spring wires across a translucent screen.

TIPPING POMONA

TWO new retractable test tip probes have been introduced by Pomona Electronics. They are designed specifically to test and measure electronic components in tight spaces with limited access, and feature a hardened stainless steel tip that penetrates conformal coatings, painting and oxidation.

The tip can extend up to 7·7cm, is fully insulated and has 1·2 metre leads that fit most meters, including Fluke, Meterman, Agilent, Amprobe and Greenlee.

For information on Pomona's test accessories, or to order a copy of their catalogue, contact Pomona Electronics Europe, Dept. EPE, PO Box 1186, 5602 BD Eindhoven, Netherlands, or visit **www.pomona.com**.

TELE-JUMP

DIGITAL photographers, Barry Fox tells us, can now instantly jump closer to their subject, without moving an inch, and without any loss of picture quality. Panasonic's Tele-Jump exploits the fact that the CCD image sensor in a modern camcorder is designed for capturing still pictures on a memory card, as well as moving pictures on tape. The sensor has a matrix of 1024 × 768 pixels which gives the clarity needed for stills. This is too much for movie tape, so the image must be electronically downgraded to 720 × 576 pixels for moving pictures.

Pushing the new Tele-Jump button uses only the central area of the sensor, 720 × 576 pixels in size, without any downgrading. So a head and shoulders shot instantly zooms to a face-only picture.

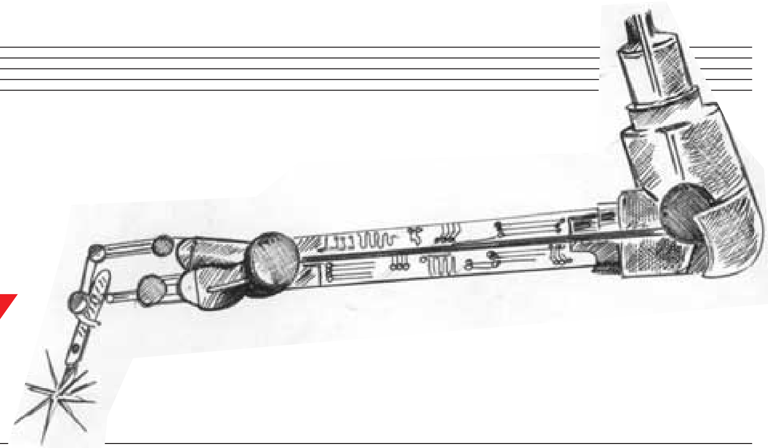
HANDS OFF!

"The stork has landed!" states a press release from Urathon, continuing: "Urathon are pleased to announce the arrival of the Car Baby – one cute baby that won't tug at your purse strings, and you will love it for ever with hardly a gurgle and certainly never a scream".

Whatever your feelings about such expressions, Car Baby converts your mobile phone into a hands-free set with no wires and no earpiece. It is compatible with all makes of mobile, with no conversion kit, clipping over your mobile and sending the caller's voice to your car's radio and speaker. Conference calls are said to be easy, as the unit picks up the voices of everyone in the car.

Car Baby costs £24.95, including VAT, and is available from Urathon Europe Ltd., Dept. EPE, Thane House, Hilmarton, Wilts SN11 8SB. Tel: 01249 760581. Fax: 01249 760547. Email: sales@urathon.com.

CIRCUIT SURGERY



ALAN WINSTANLEY
and IAN BELL

Our team of monthly surgeons revisit Darlington transistors and the Sziklai connection, plus a roundup from our postbag on the topic of soldering.

Back to Darlington

In the June 2002 issue of *Circuit Surgery* we briefly described the Darlington transistor and similar configurations, which use two transistors to obtain a transistor action with higher gain and/or input impedance than is available from a single device.

Perhaps we were a little two brief, as reader ***Ron Harrison*** pointed out in an email to us. The second configuration in Fig.3 in that article (page 439) is a compound *pnp* transistor and illustrated a variation of the Darlington theme that was not actually described in the text, which may have been a little misleading.

To make matters worse the labelling of the effective emitter and collector connections was incorrect in that figure! The emitter and collector labels should be transposed in the right-hand configuration given.

To help overcome any confusion, in Fig.1 this month we show both *npn* and *pnp* versions (a) and (b) respectively, of both the Darlington, and the other less well known compound transistor configurations (c) and (d).

Sziklai Pair

We will take a more detailed look at this latter transistor pair, as readers may be less familiar with it than the Darlington pair. One of the main features of this alternative compound transistor – which is known as a Sziklai pair or Complementary Feedback Pair (CFP) – is that it only requires a single V_{BE} voltage to turn on, unlike the Darlington which has an effective V_{BE} equal to two V_{BE} drops.

Therefore, the Sziklai has the advantage of being able to be "plugged in" in place of a single transistor, and the lower effective V_{BE} does not compromise its use in low voltage circuits (an important concern in modern chip design). The CFP also has lower output resistance than the Darlington, about one tenth of the value when used in a common-emitter-style configuration under the same quiescent conditions.

The CFP is typically biased using a resistor as shown in Fig.2, where R1 is selected so that most of the current in TR1 flows through R1 rather than the base of TR2. This means that the quiescent current in TR1 is well defined and does not depend on the gain of TR2 and its collector current. The collector current of TR1, I_{C1}, is approximately V_{BE2}/R1 if we assume that

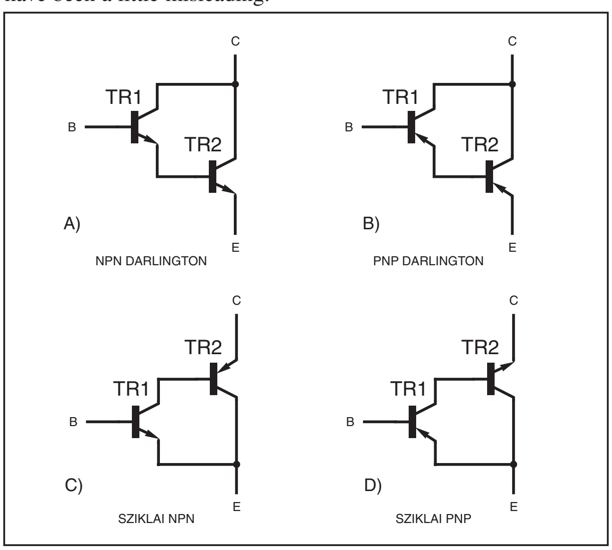


Fig.1 (above). Darlington and Sziklai Pairs (or CFP).

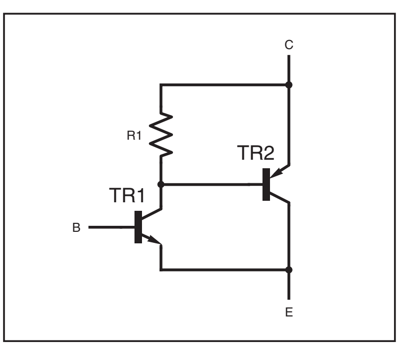


Fig.2 (left). CFP with bias resistor.

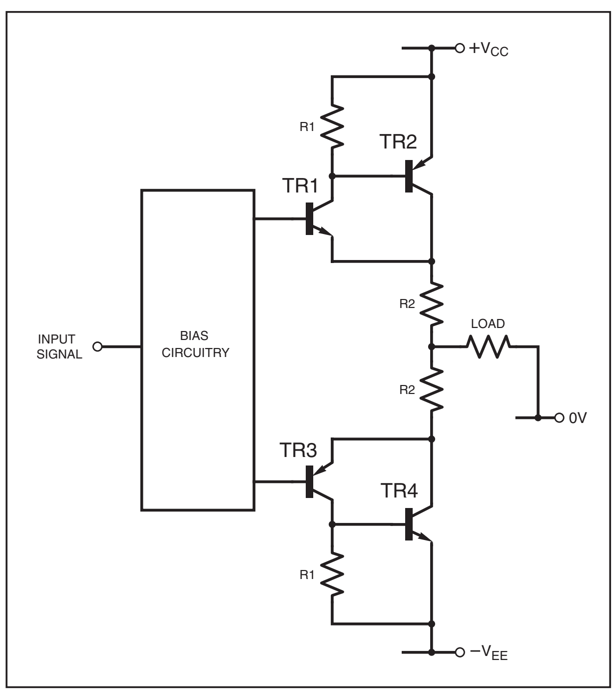


Fig.3 (right). CFP used in power amplifier output stage.

TR2 has a high enough gain for I_{B2} to be significantly smaller than I_{C1}.

Typically we want TR1 to have a quiescent current about one tenth of that of TR2 so, given this assumption, and given that we probably choose I_{C2} as a key design parameter, we get

$$R1 = 10V_{BE2}/I_2,$$

where as usual V_{BE2} would typically be between 0·6V and 0·7V.

CFP Amp

A typical use of the CFP is in audio power amplifier output stages where it delivers better (at least according to its proponents) performance in terms of thermal stability and large signal non-linearity due to the feedback effects within the transistors pairs (hence the CFP name), although these effects are reduced at high frequencies.

In Fig.3 we show the schematic of a typical power amplifier output stage based on the CFP in which the transistor pairs are used in the same way as a standard push-pull emitter follower output stage. The pair TR1-TR2 handles the positive half of the signal, and the pair TR3-TR4 handles the negative half. The bias circuit ensures that the transistors switch on for the correct part of the signal waveform (for example to prevent crossover distortion).

The *pnp* Sziklai pair has played a role in integrated circuit design for a long time, particularly in essentially *npn* processes that allowed fabrication of good *npn* transistors, but which only provided low gain *pnp*s. The compound transistor provides a means of obtaining a high-gain *pnp* in these technologies.

You may be interested to know that the use of enhanced transistors built from more than one transistor does not stop at the configurations discussed here. For example, in 1990 Bult and Geelen published a design of an op.amp built using high performance "Super-MOS" transistors. The Super-MOS is a circuit which is built from no less than 12 ordinary MOS transistors, but behaves like a very high gain MOSFET which is also "self biasing" and therefore easy to use. *IMB*.

Soldering Tips

One of the joys of hosting the world's most popular Internet guide on soldering (**www.epemag.wimborne.co.uk/solderfaq.htm**) is the great diversity of questions that arrive by email. Soldering is of course not confined to electronics – many other materials are soldered as well, from brass Tiffany lamps to the refrigeration piping of a cooler being restored in a Greyhound bus! A lot of time is spent behind the scenes at *Circuit Surgery* trying to help correspondents all around the world with their soldering techniques, and here are a few recent items from the *EPE* mailbag – as you'll read, we may not always know the answer but we will try to give some pointers.

I am working on the Scottish Parliament building using 0·5mm Low Lustre Stainless Steel Longstrip sheeting and I have to solder some joints. I would like to know the life expectancy of soldering and I wonder if you could advise or point me in the right direction where I can get information on this. ***TM*** by email.

I checked for suitable solder on **www.multicore.com**. Multicore suggest a Tin-Silver solder (Sn/Ag 96·5/3·5) only, together with an inorganic acid flux or solder paste e.g. AC10 would be suitable for use with stainless steel. Electronics solder has built-in flux to help it flow, but in other industries, a separate flux paste is applied. Never should you need to apply acid flux when soldering electronic components!

What I'm not sure about is the longevity of the soldering in this application. If it's external then it is likely to be affected by pollution (acid rain, caustic cleaners etc.), also any mechanical flexing will cause fatigue to the soldering. The expansion of metal in heat might give rise to this. I know that dissimilar metals in contact with salts will give rise to corrosion, and I know that different grades of stainless steel will be adversely affected by this. Contrary to popular belief, stainless steel can be attacked by chemicals and there are different grades of steel available to counter this problem. If it is indoors then the material is likely to last for decades but if your work has to brave the Scottish weather then I'm not sure.

I suggest you start by contacting CIBSE, the Chartered Institution of Building Engineers **http://www.cibse.org** who may be able to point you to a specialist or consultant or another organisation. *ARW*.

Defense de fumer

I read your online soldering guide and I have a question which I really hope you can answer. You said that solder contains about 60% lead, well I'm using Radioshack "High-Tech Rosin-Core Solder" and I had an incident with it when I was working with it for five hours straight and I got REALLY sick, I had to be taken to the hospital and was out of commission for a week. Now when I solder, I use a 3M respirator designed for painting, I don't really know it that blocks the fumes though, do you know anything about this? ***GZ*** by email.

You are totally right to take any sensible precautions, though wearing a respirator is not something I've seen in this application, as it would be too unwieldy. There are different types of filter cartridges available for use against e.g. organic vapors or solvents, and solvent-proof filters and suitable masks are available from larger DIY stores.

You may be very sensitive to the fumes given off by the smoking flux. In the UK and the USA there are very strict regulations on exposure to chemicals and fumes in the workplace. A manufacturer's materials safety data sheet (MSDS) offers guidance in relation to the safe use of their products. At home though, hobbyist constructors work under no such restrictions and will blithely work into the night, inhaling solder fumes, dealing with ferric chloride etchant, handling lead-tin solder and generally having a great time in the process!

One item I always suggest for anyone keenly interested in electronics, is a bench-top solder extractor to duct irritating fumes away from the eyes and nose (see photos). They contain an activated charcoal filter to neutralise the fumes. Without doubt, fumes from melting rosin-filled solder can be highly irritating, and I know of some engineers who are sensitive to this form of irritation, perhaps having formed an allergy. One correspondent uses an old cylinder vacuum cleaner with a long hose that suck fumes away from the bench. *ARW*.

A benchtop fume extractor contains a fan which draws the fumes through a charcoal filter and away from the work area. They have a "range" of about 12 inches or so.

The best solder wire

I have visited your web site and found it very interesting. There is lot of info regarding soldering, a very nice site. I want to know which type of solder wire is good for professional use. I mean 60/40 type, eutectic 63/37 or NO CLEAN type. Please advise me the best solder wire. ***Arif Deshmukh*** by email.

It depends on what you're trying to solder. "Best" depends on the criteria – cost? reliability? efficiency? A good place for advice is **www.multicore.com** who make a wide range of solder wire which is sold through all the major distributors. Personally I use 60/40 tin/lead for all my hand soldering. Some engineers use silver solder or "Smart Wire" for the best possible finish by hand.

The combination of metals used in the alloy also affects the price. You can buy 60/ 40 or 40/ 60 tin/lead, the latter being somewhat cheaper. A quick look on the London Metal Exchange at today's prices reveals why: lead costs $454 per tonne but tin costs ten times more at $4,425 per tonne. Copper costs $1,606 per tonne if anyone's interested (no circuit should be without some).

Coming to an electronics workbench near you sooner rather than later, is the prospect of lead-free solder, which may well become compulsory in due course for environmental reasons (it already is, in the plumbing industry). It typically contains 99·7% tin and 0·3% copper and weight for weight it is double the price of 60/40 solder. I have had very mixed reports about the use of lead-free solder in electronics, and it's a topic I will be covering in the future. Feedback on this from readers would be welcomed. *ARW*

Constructional Project

PORTABLE TELEPHONE TESTER

ALAN PATON

Make the right call with this low-cost, easy-to-use, telephone checker

When looking around car boot sales, radio rallies etc. you will often see telephones for sale. They can be second-hand, new or surplus stock and since they do not have a guarantee there is always a risk when buying them that they may be faulty. Until now there has been no easy way to perform a basic test on a telephone where a working telephone line is not at hand.

However, the Portable Telephone Tester described here will check the basic functions of a telephone without using a telephone line, and it is easily portable . It can, if you wish, even be used in the middle of a field (car boot sale) or anywhere where you are likely to find a telephone for sale.

RALLYING CALL

The occasion that really prompted the design of this tester happened when visiting a radio rally. One of the stalls at the "meet" had about a dozen boxes on it, each containing quite an unusual type of telephone. They were priced at £5 each and they appeared to be a real bargain – *IF* they were working! The stallholder said that they were all OK, but then they always do!

The purchase of two or three was contemplated, but the author could not justify taking a chance on what could turn out to be a box of scrap metal. Because of this only a single phone was bought.

It turned out to be an excellent telephone which has been in constant use to this day. It was this incident that made the author realise just how useful a portable telephone tester would be.

Considerations to be taken into account when designing a telephone tester are that telephones usually work at higher voltages than are generally available with portable equipment. In addition, the ringing current required is a low frequency (approximately 20Hz) high voltage alternating current.

The Portable Telephone Tester uses just one 9V (PP3 type) battery which has been found to be sufficient for testing speech paths and pulse tones. The a.c. ringing current is derived from a two-transistor multivibrator driving a "reverse connected" mains transformer. The whole tester fits into an ordinary electrical pattress mounting box.

CIRCUIT DESCRIPTION

The full circuit diagram for the Portable Telephone Tester is shown in Fig.1.When the function switch S1 is set to the Test position, power is applied to the telephone Line socket SK1, contacts 2 and 5. This will initially light the l.e.d. D1 indicating that the battery supply is present. The l.e.d. is a high brightness type since the tester will sometimes be used in daylight.

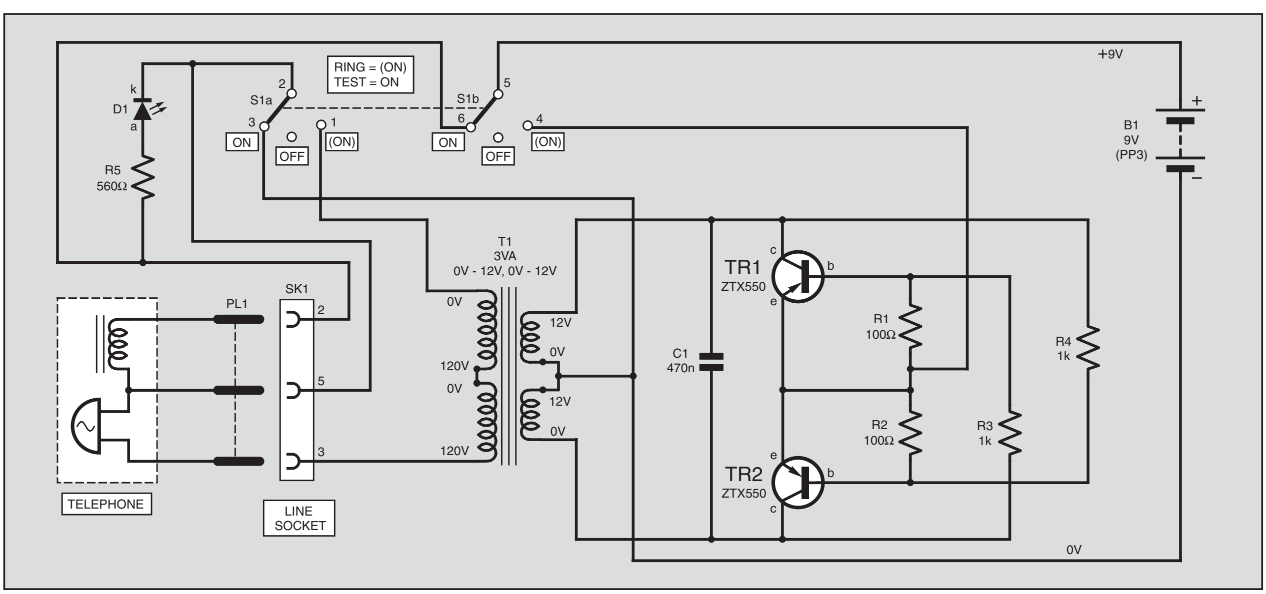


Fig.1. Complete circuit diagram for the Portable Telephone Tester.

The battery will also provide power for the telephone, when plugged in, and enables a number of tests to be carried out. These are set out in the separate "Using the Tester" panel.

When switch S1 is held in the biased Ring position, the multivibrator circuit, made up of transistors TR1, TR2 and associated components, is powered up generating a high voltage alternating current (a.c.) at the output of the "reverse wired" transformer T1. This is the ringing current which is applied across the Line socket contacts 3 and 5 to ring the "test" telephone bell or sounder depending on the type of phone being tested.

Being the "biased" position, releasing the switch actuator toggle/dolly will automatically cause it to spring back to the centre-off position, cutting the supply and terminating the ringing.

POWER CALL

When the tester is switched to Test it will consume 12mA to light l.e.d. D1. With a telephone plugged in and the receiver lifted this rises to 35mA to 45mA approximately, depending on telephone type. When switched to Ring the current drawn is 150mA approx., although this will typically be for only 1 or 2 seconds.

The a.c. voltage measured at contacts 3 and 5 of the Line socket SK1 (i.e. the output of the transformer T1) will be about 118V a.c. off load, when using a DVM switched to the a.c. range. With a telephone plugged in, the measured voltage will be around 78V a.c. this will vary slightly depending on the phone used. ***Take care not to touch this high voltage.*** The frequency measured should be about 22Hz.

CONSTRUCTION

Most of the components for the Portable Telephone Tester are mounted on a small piece of stripboard, size 30 holes × 12 strips. The topside component layout and details of breaks required in the underside copper tracks are shown in Fig.2. This board accommodates all of the components except the power indicator l.e.d./resistor (R5) and the battery. The l.e.d. and resistor are mounted directly on the Line socket panel.

Commence construction by inserting and soldering in position the six link wires; these can be made up from discarded resistor leads. This should be followed by the p.c.b. mounting transformer as the pin terminations are located beneath it. The specified transformer has pin spacing of 0·2in. which should provide an exact fit on the stripboard.

Next, the resistors (except, of course, R5) and capacitor should be soldered in position on the board. The last components to be soldered in place are the two transistors and care should be taken to check that they are the right way round (see Fig.2) before introducing the hot soldering iron to their leads.

Finally, multi-coloured stranded leads of about 150mm in length should be attached to each end of the circuit board as indicated in Fig.2. This should also include the battery clip leads. This completes the circuit board construction and, for the moment, it should be put to one

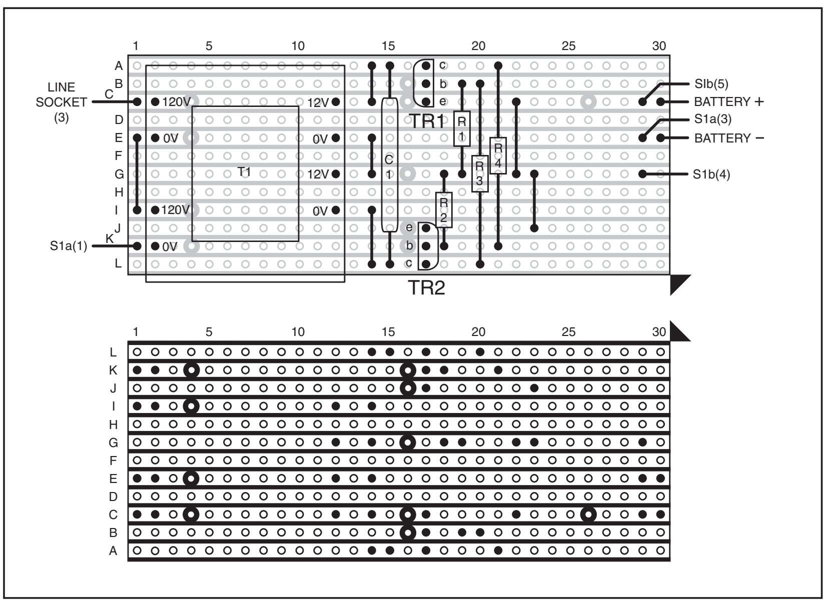
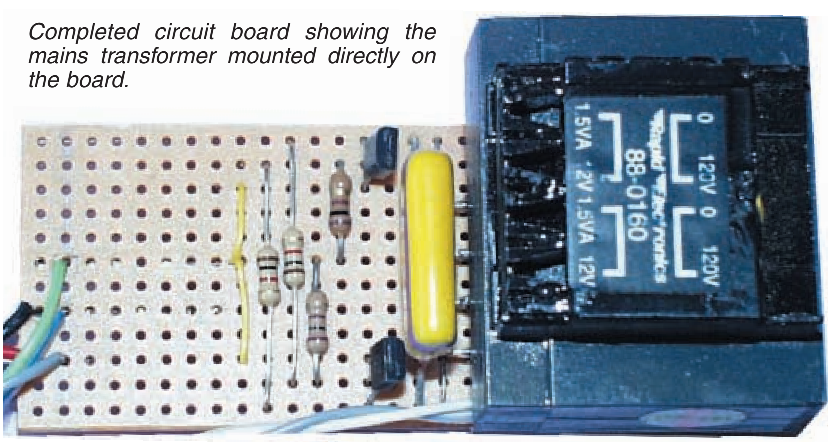


Fig.2. Portable Telephone Tester stripboard topside component layout and details of breaks required in the underside copper tracks.

Completed circuit board showing the mains transformer mounted directly on the board.



COMPONENTS

Resistors
- R1, R2 100Ω (2 off)
- R3, R4 1k (2 off)
- R5 560Ω

All 0·25W 5% metal film

See **SHOP TALK** page

Capacitors
- C1 470n polyester film, 100V d.c.

Semiconductors
- D1 5mm superbright red l.e.d.
- TR1, TR2 ZTX550 medium power *pnp* transistor

Miscellaneous
- S1 d.p.d.t. sub-min toggle switch, centre off, non-locking one way and locking the other (On-Off-On (biased))
- T1 3VA min., p.c.b. mounting, mains transformer: twin 120V a.c. primaries; twin 12V a.c. secondaries
- SK1 flush-fitting, BT type, secondary line jack, with screw terminals
- B1 9V battery (PP3 type), with clips and leads

Stripboard 0·1in. matrix, size 30 holes by 12 strips; plastic surface pattress box (84mm x 84mm x 46mm depth), single; 5mm l.e.d. recessed mounting clip; multi-strand connecting wire; solder pins; solder etc.

Approx. Cost Guidance Only **£12** *excl. batts.*

side on the workbench ready for final wiring up later.

BOXING -UP

We now need to turn our attention to the electrical surface mounting box, which, together with the Line socket, forms the "case" for the Tester unit. Sometimes called a 1-Gang Pattress Box, it must be the deep type (46mm approx.); any shallower and there will be no room for the transformer.

To enable the stripboard to fit into the box any excess plastic moulding inside, which looks as though it will be in the way, will have to be removed. Different makes have different shapes of internal plastic but it is necessary to make each of the sides, without the screw mountings, reasonably flat on the inside.

Probably the best tool for cutting out any protrusions would be an art knife or sharp chisel. However, the author used a small one inch diameter grinding wheel on an electric drill. The only problem with this method is that it does create a dust problem.

Once space has been made for the circuit board we need to drill a 6mm dia. hole for the test switch S1. This is located in the top side-wall as indicated in Fig.3.

We also need to drill a 8mm dia. hole for the l.e.d. mounting clip in the telephone line socket. The suggested position and drilling details for the l.e.d. is also shown in Fig.3. The top half of the p.c.b.

USING THE TELEPHONE TESTER

It is worth testing your own telephone at home first to familiarise yourself with the tester before taking it out to a radio rally or car boot sale.

ACTION	RESULT
1. Switch to TEST – no phone connected	L.E.D. lights (battery indicator)
2. Plug in telephone – after checking that receiver is on rest	If l.e.d. goes out or very dim this suggests short circuit on telephone
3. L.E.D. remains bright. Lift handset and blow into microphone.	You should hear your own "blow" in the receiver speaker. This simple test shows that the microphone and receiver are working

Note: If no "blow" is heard when testing unknown telephones try moving the handset and telephone cords while continuing to blow into microphone. The cords sometimes have intermittent faults that will show up in this test.

4. Press each of the keys on the keypad while listening to the receiver	Various tones should be heard in the receiver. This confirms that the keypad is working.

Note: If no tones occur or a "clicking noise" is heard, check that switch on the base of phone is switched to tone (sometimes marked P and T for Pulse and Tone). Old telephones may only produce "pulses" and are not suitable for use with tone only systems, although they should be OK on the BT network.

5. Replace handset and switch to RING	Bell or sounder should ring

If not – check switch marked On-Off or Hi-Lo on base of phone and repeat test. Try the high and low rings to confirm that they both work.

If it passes all of the above tests you should have a healthy telephone.

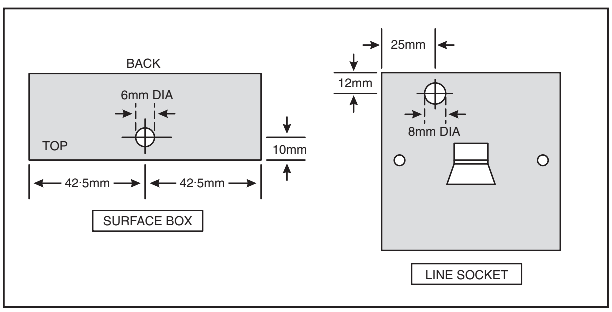


Fig.3. Suggested positioning and drilling details for the test switch (left) and (right) power indicator l.e.d.

The deep pattress electrical surface mounting wall box after the necessary internal plastic obstructions have been removed.

Layout for components in the two-halves of the case. Note that the cable-tie around the transformer secures the circuit board to the bottom of the surface box.

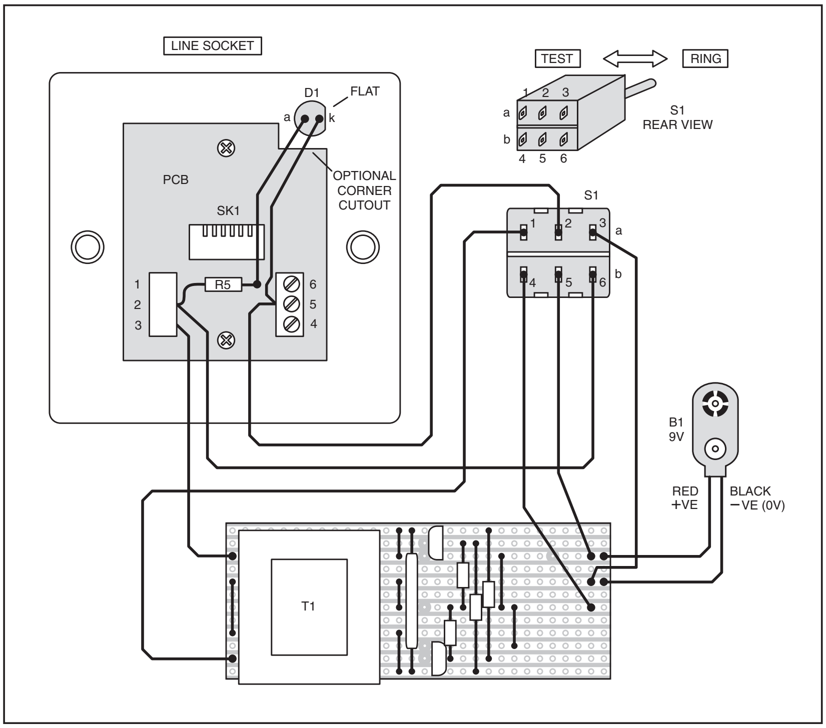


Fig.4. Interwiring from the circuit board, line socket and the test switch. The switch is viewed from the rear as it appears when mounted in the box.

(printed circuit board) in the specified extension type socket is not used, so a small piece can be cut off one corner to make room for the l.e.d. and its leads, without affecting the functioning of the socket.

ASSEMBLY AND WIRING

When the preparations of the box and line socket have been completed, we can now proceed with the final assembly and wiring up. At this stage it is a good idea to mount the circuit board and biased function switch S1 into the pattress box. In the prototype, the circuit board is held in position by looping a cable tie over the board-mounted transformer and passing it through two holes in the bottom of the box, see photographs.

Before we take the "loose" ends of the leads from the board and wire them to switch S1 and the Line socket screw terminals, the l.e.d. D1 and resistor R5 need to be connected up. The full wiring details are shown in Fig.4.

When wiring the switch make sure that it has the correct orientation; biased action to the right when viewed from the top of the box (see photographs). The wires to the switch can be taken through a length (20mm approx.) of sleeving (heatshrink will do) to keep wiring tidy. When all the wiring has been completed and the "power" l.e.d. and battery connected up, the line socket and the pattress box can be screwed together.

If the finished unit, together with a known working phone, passes all the checks outlined in the accompanying Test Panel, you now have a "take-it-anywhere" Portable Telephone Tester for your next trip to the local car boot sale or Radio Rally. ☐

SHOP TALK
with David Barrington

Freebird Glider Control

Apart from the model glider, the servo motors are the next most expensive item required for the *Freebird Glider Control* project. The author obtained his from **Maplin** (☎ **0870 264 6000** or ***www.maplin.co.uk***) together with custom servo leads and plugs and sockets. We understand that the servo motor is a bit big and heavy and it might be a good idea to investigate your local model shop to see if they have something smaller and lighter.

If you wish to use the Maplin servos, you should quote order code FS35Q and codes GZ87U (lead), GZ93B (skt) and GZ94C (plug). Good gliders can be found at ***www.hobbystores.com***.

The author used mercury tilt switches in his glider, but as mercury is such a dangerous and toxic substance, we recommend that they are replaced with non-mercury types. A suitable alternative, "non-mercury", hermetically sealed tilt switch is listed by the above company and can be ordered by quoting code DP50E.

For those readers unable to program their own PICs, a ready-programmed PIC16F84A-20 (20MHz) microcontroller can be purchased from **Magenta Electronics** (☎ ***01283 565435*** or ***www.magenta2000.co.uk***) for the inclusive price of £5.90 each (overseas add £1 p&p). The software is available on a 3·5in. PC-compatible disk (*EPE* Disk 5) from the *EPE* Editorial Office for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 691). It is also available *Free* from the *EPE* ftp site: **ftp://ftp.epemag.wimborne.co.uk/pub/PICs/Freebird**.

The Freebird printed circuit board is available from the *EPE PCB Service*, code 367 (see page 691).

EPE Morse Code Reader

There should not be any problems finding a suitable two-line 16-character per line alphanumeric l.c.d. module for the *EPE Morse Code Reader* as connection details are included for the two "standard" formats. The one used in the author's model came from **Magenta Electronics** (☎ ***01283 565435*** or ***www.magenta2000.co.uk***) and is competitively priced.

For those readers unable to program their own PICs, a ready-programmed PIC16F84-4 (4MHz) microcontroller can be purchased from Magenta Electronics (see above) for the inclusive price of £5.90 each (overseas add £1 p&p).

The software is available on a 3·5in. PC-compatible disk (*EPE* Disk 5) from the *EPE* Editorial Office for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 691). It is also available for *FREE* download from the *EPE* ftp site, which is most easily accessed via the click-link option at the top of the home page when you enter the main web site at **www.epemag.wimborne.co.uk**. On entry to the ftp site take the path **pub/PICs/Morse**, downloading all files within the latter folder.

If problems arise trying to find a local source for a suitable sub-miniature omni-directional electret microphone, both **Rapid Electronics** (☎ ***01206 751166*** or ***www.rapidelectronics.co.uk***), code 35-019 and **Maplin** (☎ ***0870 264 6000*** or ***www.maplin.co.uk***), code FS43W, can supply. Take care, they are tricky to solder leads to their pads.

The Morse printed circuit board is obtainable from the *EPE PCB Service*, code 368 (see page 691).

Portable Telephone Tester

The electrical pattress or surface mounting box, which makes up one half of the Portable Telephone Tester case, should be available from any good electrical store. However, it must be the deep type (46mm deep or more) if it is to house the transformer and allow the line socket to close on the mounting box. The one in the model came from **Maplin** (☎ ***0870 264 6000*** or ***www.maplin.co.uk***), code ZB40T.

They also supplied the BT type, flush-fitting, telephone secondary line socket (with screw terminals). This should be ordered as code FJ34M. The two-pole sub-miniature centre-off, biased non-locking one way and locking the other, switch used in the prototype also came from the above-mentioned source, code FH06G.

The 3VA miniature, p.c.b. mounting, mains transformer with twin 120V a.c. primaries and twin 12V a.c. at 0·12A secondaries was purchased from **Rapid Electronics** (☎ ***01206 751166*** or ***www.rapidelectronics.co.uk***), code 88-0160. If any readers experience difficulties sourcing the medium power ZTX550 60V *pnp* transistor, it is also stocked by them, code 81-0212, and by **ESR Electronic Components** (☎ ***0191 251 4363*** or ***http://www.esr.co.uk***).

One final comment, take care not to touch the "high voltage" pins of the transformer when the circuit board is powered up.

Vinyl To CD Preamplifier

Only a couple of items may cause concern when purchasing components for the *Vinyl To CD Preamplifier* project. The interlocking, spring-loaded, pushbutton switch which mounts directly on the printed circuit board (p.c.b.) came from **Farnell** (☎ ***0113 263 6311*** or ***www.farnell.com***), code 733-155.

The p.c.b. must be housed in an all-metal case to provide some protection against hum pick-up. If you wish to use the same case as the author, it appears to be from the Maplin aluminium instrument case range and is the Blue 212 version, code XY43W.

The printed circuit board is available from the *EPE PCB Service*, code 368 (see page 691).

New Technology Update

Is this the next quantum leap in computing technology? asks Ian Poole

LOOKING to the future there appears to be no less change on the horizon as new methods and technologies are required to keep pace with the increasing requirements being placed upon computing technology. Current technologies will be able to meet the demands for the near future, but new and more revolutionary ideas are being investigated for the longer term.

Not all of the technologies being investigated will come to fruition, but one exciting development that shows a lot of promise is associated with ion trapping. Here the interaction between light and matter on an atomic scale is used as the basic principle of operation. By adopting this approach revolutionary new developments can be made, providing the possibility for major advances.

Over the years a number of institutions have carried out work in this area. This has now been brought together and a proposal made for a quantum computer. Whilst the computer itself has not been built and one will not be available for many years, the basic building blocks are now being tried and tested. Researchers from the National Institute of Standards (NIST), Massachusetts Institute of Technology (MIT) and the University of Michigan have been working together and they have recently reported their findings in *Nature*.

Basic Concept

Current computers operate using binary numbers and use two states, namely "on" or binary 1 and "off" or binary 0 to represent numbers. A quantum computer makes use of the properties of quantum mechanical systems rather than transistors. Here the everyday principles we all know and accept seem not to hold and many new and unusual properties seem to be present. Those who have studied quantum mechanics and know of laws such as Heisenberg's Uncertainty Principle may understand.

Using Quantum Mechanical principles it is found that atomic particles can exist in several states simultaneously. This is based on what is known as the superposition principle that indicates that a quantum mechanical system such as an atom can exist in several energy states or spin directions until it is actually measured.

Bursts of light can flip the bits in various ways, independently changing various values and creating a logic gate that enables calculations to proceed down many different paths at the same time. When a calculation is complete it can be extracted and measured again using light pulses.

This means that they can be used to manipulate many times more information than would be possible with a traditional computer, leading to a major leap on the processing power of such a machine when compared to what is possible today. Ideas for such computers could include performing virtually real simulations on the world's weather or many other applications requiring huge amounts of processing power.

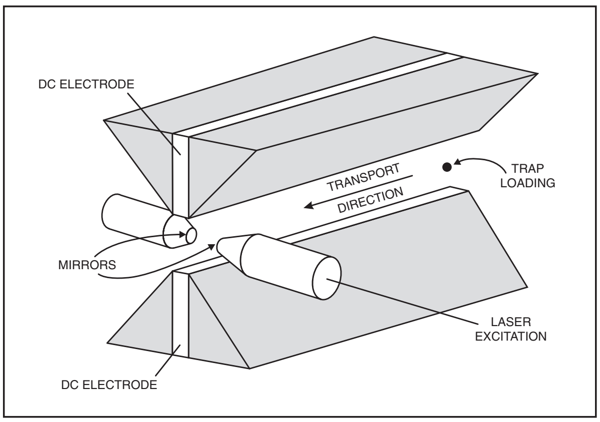


Fig.1. A form of ion trap

Ion trap

The basic building block of the computer would be an ion trap. These traps are places where ions can be stored, observed and manipulated. Whilst the possibility exists of manipulating large numbers of ions in each trap, this currently presents immense technical difficulties. Nevertheless it is feasible to use tens of ions in each trap.

The Quantum Computer or QC itself would be built from a number of traps and the research team called the architecture a "quantum charge coupled device" (QCCD). By changing the voltages on the ion traps a few ions can be confined in the trap or it is possible to shuttle ions from one trap to the next. It is possible to manipulate ions in any given trap, whilst moving them from one trap to the next enables communications. In this way it is possible to provide both memory and logical functions required in a computer.

Trapped ions storing quantum information are held in the memory region. To perform a logical function the relevant ions are moved into an interaction region. This is achieved by applying the correct voltages to the appropriate electrodes.

It is within the interaction region that the logical processes are carried out. Here the ions are held close together to allow coupling. Laser light is then focussed on the region to drive the gates and once the action is complete the ions are moved ready to prepare for the next action.

Realisation

A number of structures have been fabricated for the QCCD. This is relatively easy using current methods. Ion traps have been made by machining slits in alumina wafers using lasers and then evaporating gold onto alumina to act as the electrodes. Although these traps are experimental, they have virtually the same dimensions that would be required for the QCCD computer. As an alternative technique other structures are being fabricated from heavily doped silicon, using micro-fabrication techniques.

The first ion traps have now been interconnected in what is a major step forwards in creating the computer. The traps used were very similar to those used when demonstrating the functionality of the individual ion traps and their separation is 1·2mm. Using the structure, quantum data bits or qubits have been successfully transferred with transport times as short as 50 microseconds being observed.

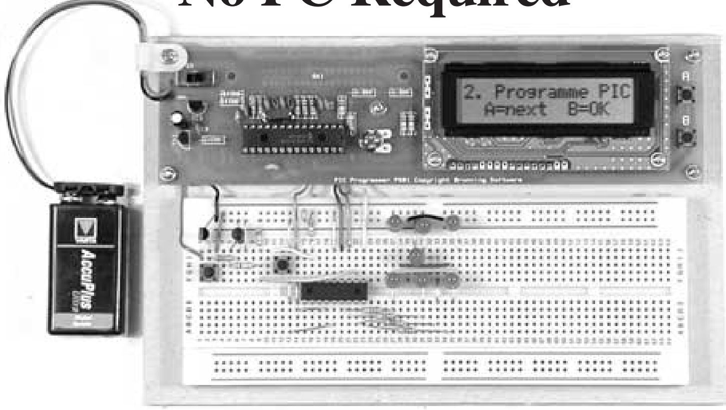
For successful operation the system has to be cooled. It is also found that the ions need to be cooled after they have been transported between the two traps. This is achieved by using what is known as sympathetic cooling where different types of ions to those that are transported are used. By confining both types of ion to the interaction region enables the cooling ions to act as a heat sink.

Future

This work is claimed to be the first presentation of a realistic architecture for quantum computation that is scalable to large numbers of qubits. Although many other organisations are working in similar fields, this proposal is built upon work that has already been tested experimentally, and it now appears that there is a straightforward path to increasing the scale of the individual items to build a complete computer.

Whilst the basic building blocks have been tested, there is still a major amount of work to be undertaken before these computers may be realised on a workable scale. This means that it will be many years before this new technology becomes established as a serious contender to the semiconductor based machines we currently use.

No PC Required



Electronics and Microcontrollers For Absolute Beginners

Now with our new beginners system you can learn about microcontrollers without needing to own a PC. 26 fascinating experiments teach the fundamentals of electronics. In the first 6 experiments we learn how to use resistors, capacitors, diodes, transistors and MOSFETs. Then we work through 20 experiments using a PIC microcontroller with progressively more complex circuits. The test microcontroller needs to be programmed with 21 different routines and all of these are contained within the microcontroller which is at the heart of the programmer module. The system requires no external data so a PC is not required.

Low cost PIC programmer module
+ Book Electronics & Microcontrollers for Beginners
+ Components for 26 experiments
+ PIC16F627 test PIC

Total price with programmer module supplied unmade (P602) £55.00
Total price with programmer module supplied made up (P601) £79.50
UK Postage and insurance . . . .£ 5.00
(Europe postage & Insurance . . . . .£12.00. Rest of world . . . . . .£18.00)

Electronics & Microcontrollers for Beginners

This book introduces complete beginners to the world of modern electronics using the most natural way of learning. We start by learning about resistors, capacitors, diodes, light emitting diodes, transistors and MOSFETs in an easy practical way. We then wire the simplest possible microcontroller circuit which just switches an LED on and off. We single step through the programme to see exactly how the microcontroller uses its output port to control the LED. We add a push button to the circuit and experiment with a time delay programme. We add two more LEDs and experiment with simulated traffic lights control. We use the microcontroller to generate sound. First a simple tone then more complex sound patterns.

The next task is to create a freezer thaw warning device with two different failure tones. We start by studying how a microcontroller can be used to monitor temperature using its internal comparator. Five experiments lead us to a comprehensive system which monitors two temperatures –5 and –14 degrees C, and uses the microcontroller's sleep mode to save power.

Finally we work thought the design cycle to create a realistic dice machine which uses 7 LEDs in place of the dots. For this mini project we create a circuit which enables the microcontroller to turn itself off after displaying the result for 30 seconds.

Almost no theory is given yet you will learn an amazing amount of professional information. Just as a young child learns to speak correctly without being given formal grammar lessons.

Wiring, Writing and Stepping

Each experiment requires the reader to build and test a simple circuit on the plugboard using the supplied components. Building the circuit is a very important part of this teaching system. For circuits which use the PIC16F627 microcontroller the test programme is written into it directly from data that is stored in the microcontroller on the programmer module. The test system allows the less complicated test programmes to be single stepped so that the operation of each stage can be studied. The instruction that is about to be processed is displayed on the liquid crystal display.

Unmade System £55.00

The unmade system (order code P602) is supplied as a kit. Before you can begin the experiments you will need to assemble and solder the programmer module and thermistor lead assembly. To do this you will need good soldering and PCB assembly skills (or know someone who has). Detailed wiring instructions and circuit diagram are included in the book. The unmade system also requires the links to be cut to size and stripped.

Made up System £79.50

The made up system (order code P601) is supplied with the programmer module assembled and tested, the thermistor lead assembled and water proofed, and with the links cut to size and stripped. The entire book can be worked through without needing a soldering iron.

Professional Users

Our low cost programmer uses the PICs in their low voltage programming mode which considerably simplifies the circuit. But this does mean that one less input/output line is available from the microcontroller. The Brunning Software universal mid range PIC programmer module does not have this limitation.

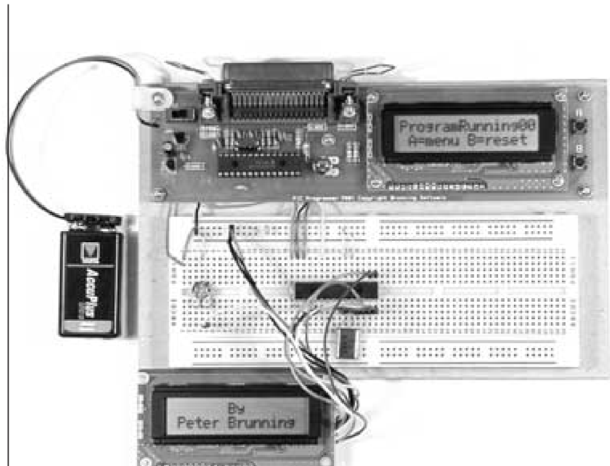
If you intend to delve deeply into PIC programming by all means begin with our low cost system to get the easiest start but we then recommend that you purchase our P401 'PIC Training and Development System' which includes our universal mid range PIC programmer module.

Tools required

To build the experimental circuits on the plugboard you will need small side cutters, small long nosed pliers and a digital multimeter. If you assemble the PCB you will also need a suitable soldering iron, wire strippers and a small amount of resin glue to waterproof the themistor connections.

Ordering Information

Telephone with Visa, Mastercard or Switch, or send cheque/PO for immediate despatch. The prices include VAT if applicable. Postage as shown must be added to all orders.
Web site:- www.brunningsoftware.co.uk



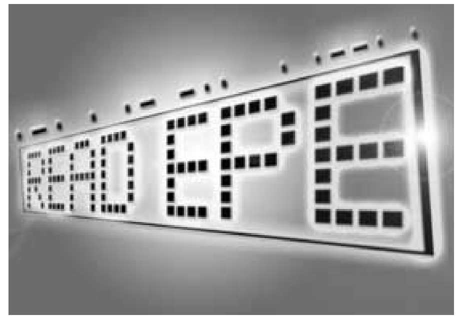
Up Grading

The low cost programmer printed circuit board has provision for a connector to be added which allows it to be driven by a PC. We have several projects in their planning stages which expand this starter system. The bottom photograph shows a working upgraded system. More information will be available when the new projects are nearing completion.

Mail order address:

Brunning Software **138 The Street, Little Clacton, Clacton-on-sea, Essex, CO16 9LS. Tel 01255 862308**

EPE MORSE CODE READER



JOHN BECKER

"View" the meaning of Morse-coded tones on the air-waves, and enhance your skills at keying your own coded messages.

MORSE is not dead! With modern communications systems abounding, it may seem so to the uninitiated, but in fact it is "alive and keying".

Whilst a cursory scan through the wavebands on a modern "normal" domestic radio receiver may reveal little in the way of Morse code transmission, this communications technique is still very much in use. Tuning in via a "communications receiver" or an older domestic receiver on the short wave (SW) bands will reveal Morse activity.

Furthermore, if you have internet access and do a search through **www.google.com** on such words as "Morse", "Morse code" and "Morse transmission", you will find literally thousands of sites devoted to the subject and its continuation in the modern world. It is, after all, an historically well-proven communications system, depending purely on switching electrical, audio or visual signals on and off at regular intervals.

Several printed publications which encourage the continued use of Morse as an "art form" also exist, of which *Morsum Magnificat* is one such in the UK.

CHALLENGING

Although the author once could claim that he knew Morse code, having been taught it (and qualified!) in the Combined Cadet Force (CCF) at school, he too had let his knowledge decline and become one of the "uninitiated". Until, that is, Editor Mike showed him an American radio publication, *Worldradio*, in which there was an advert for a small handheld Morse Code Reader, undoubtedly microcontrolled.

"Can you design one?" asked Mike. "Of course", replied the author, keen to sustain the myth that he can do *anything* with PIC microcontrollers!

In fact, he has designed several Morse decoders before. The last one being published in *Everyday Electronics* in Jan '87 (long before the merger with *Practical Electronics* to become *EPE*).

At that time PICs were probably not even a twinkle in the eye of any semiconductor manufacturer. They were certainly not reality. Consequently, the *EE* design was based on a hardware mark-space ratio detector which fed separate Morse dots, dashes and spaces via individual data lines to a pre-PC computer (Commodore PET 32K). This compiled the incoming logic into a binary format, matched it against a lookup table and displayed the results on screen.

The design presented here is physically simpler, although the software is considerably more complex (that's not your problem, though, it was merely the author's! But where's the fun in designing if it's not a challenge?).

Details on obtaining the free software, and pre-programmed PICs are given at the end.

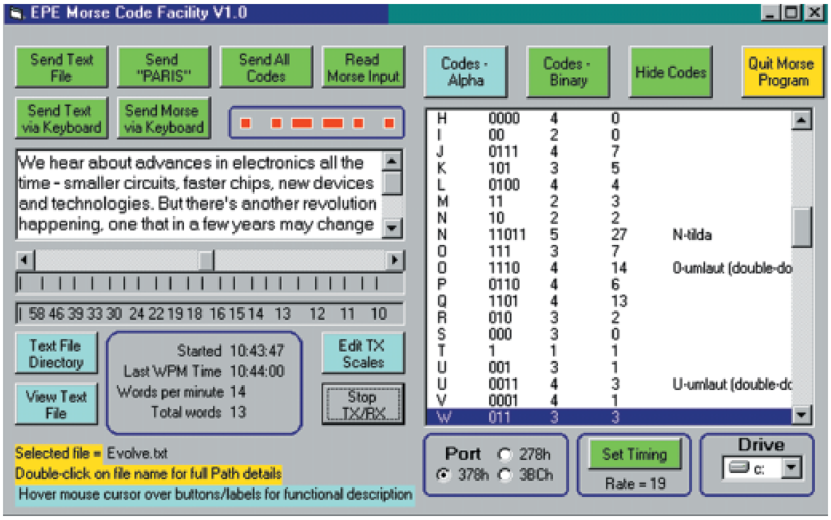
AWESOME MORSUM

There are three main aspects to this new design. It comprises:

- A handheld unit that can receive Morse code, via audio input (internal microphone) or direct signal connection, and translate it for display on an in-built liquid crystal (l.c.d.) alphanumeric screen. The received Morse signals are also available as pulses (0V/5V logic) for external use via a separate connection. Signals re-modulated at approximately 1kHz can be output to high-impedance headphones. With a suitably connected Morse key, signals can be input manually.

- Using a PC computer, Windows-based software can input the signal being repeated from the handheld unit, convert and display the code on the PC monitor, and store the translation to disk for future examination as a text file.

- The PC software can additionally be used to output Morse code to the handheld unit, for display on its screen, or monitoring as an audio signal. There are several modes of code output from the PC: translation of a text file to Morse; direct keying of alphanumeric characters for immediate translation to Morse; use of the keyboard as a Morse key with the duration of keypresses simulating Morse dots and dashes.



Typical example of the main PC screen for the EPE *Morse Code Reader.*

Several other features are also included in the PC software, as will be described later.

The handheld unit can be used on its own. It is not necessary to use it with a computer.

Various aspects of the PC software can be used on their own, too, without the need for the handheld unit. In principle, Morse code signals at normal logic levels (0V to 5V pulses) can be directly input to the computer from other sources.

The system can be used as a learning aid by those who wish to expand their understanding of Morse. It will also satisfy the curiosity of those who just want to "eavesdrop" on what radio operators are saying to each other.

TRANSLATION REQUIREMENTS

International Morse code uses the dot-dash combinations listed in Table 1. Conventionally, a dot is known as "DIT", and a dash as "DAH".

Whilst the rate of code transmission is up to the Morse operator, the relative duration of the DITs, DAHs and associated spaces has been established by international agreement:

- The DIT is the basic unit of length
- The DAH is equal in length to three DITs
- The space between the DITs and DAHs within a character (letter) is equal to one DIT
- The space between characters in a word is equal to three DITs
- The space between words is equal to seven DITs

These are the basic requirements that any human operator or translation software must observe.

The sending of Morse signals can take many forms, ranging from audio and radio transmission, modulation of light (e.g. Aldis lamps and torches), varying electrical pulse levels (e.g. sending to a computer), to bashing the water pipe if the sender is incarcerated at "Her Majesty's Pleasure"!

In audio and radio transmission, the technique is to turn the modulation of a carrier frequency (CW – continuous wave) on and off at the required rate. In audio work, the received signal is already within the audio range of the listener. Radio signals must, of course, be demodulated to become an equivalently pulsed audio signal.

There are no set rules regarding the audio frequency of Morse signals, but they must, naturally, lie in the range most likely to be heard clearly, at about 1kHz, for example.

Automatic decoding equipment, therefore, must be able to accept Morse signals as a pulse-modulated frequency. It must also be able to recognise unmodulated pulse levels originating from a voltage simply being switched on and off.

The equipment must be capable of differentiating DITs from DAHs, and letter spaces from word spaces, irrespective of the rate at which the Morse signals are being received. Ideally, it should detect if the transmission rate changes and then readjust its DIT-DAH criteria.

The author's last Morse decoder had to be manually tuned so that the software correctly recognised DIT-DAH ratios. The unit described now makes its own adjustment, typically within about eight to 16 keypresses (DITs and DAHs) being received.

Thus, all you need to do is place the unit near the loudspeaker of a radio receiver, or directly plug it into the coded signal source, and observe the unit displaying the received code as an intelligible text message.

The term "intelligible" is used loosely, of course. The unit won't translate from Swahili into English, for instance! It will simply show the letters being received. The advert mentioned earlier did actually state that its unit "instantly displays CW in English!" – a very clever device indeed if it really does that for the quoted $79.95 US!

BINARY FORMAT

If you examine Morse codes as though DITs are logic 0 and DAHs are logic 1, a binary coded pattern will be seen. Converting from binary to decimal reveals a snag, however. There are some Morse codes that have one or more "leading" DITs, i.e. leading zeros. For example, take the letters E, I, S and H, which are Morse coded as DIT, DIT-DIT, DIT-DIT-DIT and DIT-DIT-DIT-DIT (the phrase *Elephants In Straw Hats Ten Miles Off* was that taught to the author to remember these four and their three DAH counterparts T, M, O – DAH, DAH-DAH, DAH-DAH-DAH!).

With each DIT as logic 0, the binary value of each of the first four letters converts to zero decimal. Not a helpful fact if regarding Morse codes as being true binary symbols.

The answer is to also take note of the number of keypresses (DITs or DAHs - call them binary bits) in a coded letter. Now each code can be allocated two decimal numbers, its length as well as its binary value. Separate lookup tables can now be used, each dedicated to a particular code length, and then to the binary value. Table 2 illustrates the idea.

Table 1. Morse codes and their reference formats used in the PC and PIC programs.

Symbol	Code	"Binary"	Count	Number
!	··––·–	001101	6	13
"	·–··–·	010010	6	18
'	·––––·	011110	6	30
(	–·––·	10110	5	22
)	–·––·–	101101	6	45
+	·–·–·	01010	5	10
,	––··––	110011	6	51
–	–····–	100001	6	33
.	·–·–·–	010101	6	21
/	–··–·	10010	5	18
0	–––––	11111	5	31
1	·––––	01111	5	15
2	··–––	00111	5	7
3	···––	00011	5	3
4	····–	00001	5	1
5	·····	00000	5	0
6	–····	10000	5	16
7	––···	11000	5	24
8	–––··	11100	5	28
9	––––·	11110	5	30
;	–––···	111000	6	56
=	–···–	10001	5	17
?	··––··	001100	6	12
A	·–	01	2	1
B	–···	1000	4	8
C	–·–·	1010	4	10
D	–··	100	3	4
E	·	0	1	0
F	··–·	0010	4	2
G	––·	110	3	6
H	····	0000	4	0
I	··	00	2	0
J	·–––	0111	4	7
K	–·–	101	3	5
L	·–··	0100	4	4
M	––	11	2	3
N	–·	10	2	2
O	–––	111	3	7
P	·––·	0110	4	6
Q	––·–	1101	4	13
R	·–·	010	3	2
S	···	000	3	0
T	–	1	1	1
U	··–	001	3	1
V	···–	0001	4	1
W	·––	011	3	3
X	–··–	1001	4	9
Y	–·––	1011	4	11
Z	––··	1100	4	12
Á	·––·–	01110	5	13
Ä	·–·–	0101	4	5
Ch	––––	1111	4	15
É	··–··	00100	5	4
Ñ	––·––	11011	5	27
Ö	–––·	1110	4	14
Ü	··––	0011	4	3

Code	"Binary"	Count	Number		
–·–·–	10101	5	21	"starting"	These five codes not recognised by the PIC
·–···	01000	5	8	"wait"	
···–·	00010	5	2	"understood"	
···–·–	000101	6	5	"End of work"	
········	00000000	8	0	"error"	

Table 2

4-bits Bin	Dec	Char	*3-bits* Bin	Dec	Char	*2-bits* Bin	Dec	Char	*1-bit* Bin	Dec	Char
0000	0	H	000	0	S	00	0	I	0	0	E
0001	1	V	001	1	U	01	1	A	1	1	T
0010	2	F	010	2	R	10	2	N	none such		

PANEL 1. ORIGINS

Samuel Finley Breese Morse was born in Charleston, Massachusetts in 1791. Studying to be a painter in the US and Europe, in 1832 he became intrigued by the telegraph, a system first built in 1774. At that time, telegraph machines required 26 separate wires, one for each letter of the alphabet (presumably numerals had to be spelt out, and punctuation ignored).

In 1833 a German 5-wire system was introduced, but Morse recognised that a 1-wire signalling system was possible, in which a series of long and short electrical pulses could be sent in a coded order relating not only to alphabet characters but to numerals and other symbols as well.

Now known as the "American" Morse Code, the original code additionally used embedded spaces as part of the coded characters. Thus dot-space-dot represented letter "O". There were even codes that used extra-long dashes, e.g. letter "L" and numeral "0".

As the code's popularity spread, it evolved to suit the needs of international users. All embedded letter spaces were eliminated and the standardised use of dots and dashes became the code now in use, the "International" (or "Continental") Morse Code. Letter "O", for instance, has now become dash-dash-dash. Several web sites quote both code formats.

Table 1 shows the full range of allocated codes and equivalent conversion values used in the PIC software and the PC program.

It will be seen that some letters appear to be repeated but having different Morse codes, A, O and U, for example. This is because some languages (e.g. German) have letters that look similar to our "English" ones but have a double-dot above them (*umlaut*), e.g. Ä, Ö, Ü. Some letters also have "acute" and "tilde" signs as well, e.g. É and Ñ.

In this unit the codes for accented letters are recognised, but the translation is to the "standard" letter form.

Some Morse codes can have meanings that are specific phrases. For instance, DIT-DAH-DIT-DIT-DIT (01000) means "wait" and DAH-DIT-DAH-DAH-DIT (10110) means "starting". This unit's software ignores such expansions, although the optional PC interface software recognises some.

RECEPTION RATE

It will be obvious that the software must have a "base-timing" value against which it assesses DIT, DAH and space lengths. Such lengths depend on the sending operator's keying speed, which can vary considerably between operators. A novice might send at, say, only five words per minute (WPM). An experienced operator could even be sending at 50 WPM (about 25 WPM is a more typical rate).

The software assesses the sending rate by looking for the shorter pulses (the DITs). Initially, a temporary reference value is set to a high timing number, greater than the expected incoming pulse lengths. For a cycle covering the next 16 keypress pulses, each pulse timing length is compared with this reference. If it is less, the reference is set to the same value as the pulse.

The comparison is repeated for all 16 keypresses. It is then assumed that the reference value is that representing a DIT. The DAH and space values referred to earlier are then set in respect to this value. Again the reference value is set higher than the expected incoming pulse lengths and the cycle repeats.

Simultaneously with the reference value comparisons, each incoming keypress is compared against the current DIT, DAH and space lengths, and each code sequence compiled as an equivalent binary value and in relation to its bit count. During the letter spaces the equivalent character is found from the respective lookup table and displayed on screen. If a word space is found, a space character is also sent to the screen.

DIT length comparison, of course, is not fool-proof and noise or sporadic changes of operator keying rate may cause temporary misinterpretation of incoming codes, probably signified by a sequence of the letter T being seen. Usually, a recovery from such instances is made within 16 keypresses.

It was also found that when feeding the unit with computer-generated codes, slippage could still occasionally occur. This is due to the PC monitoring other aspects of its system even though it is also running the Morse program.

One PC in particular was excessively prone to this. It periodically decides that it wants to check all sorts of things on the hard drive and the floppies, thoroughly disrupting Visual Basic (and Quick-Basic) timings. The reason cannot be found (the machine came to the author second-hand).

Visual Basic does not allow internal "interrupts" to be stopped. They can be stopped if a machine code program is being run, as the author used to do when using QB with an m/c sub-routine, but he has not yet found a way to integrate m/c (8086 assembly dialect) with VB. (Advice from anyone who does know would be appreciated!)

Using a PC as the Morse source, translation rates in excess of 50 WPM were achieved with the PIC unit.

CIRCUIT DIAGRAM

The complete circuit diagram for the *EPE* Morse Code Reader is shown in Fig.1. Not much to it! Basically, Morse signals are input, amplified, translated by a PIC16F84 microcontroller and displayed on the l.c.d. screen.

Microphone MIC1 is a miniature electret type which receives its power via resistor R1 and allows the unit to be placed near the speaker of a radio receiver to pick up Morse signals without any physical connection to it.

Socket SK1 enables direct connection to, say, a radio receiver's audio output socket, low level or line-level. The microphone is automatically disconnected in this instance.

Signals from the selected source are a.c. coupled to level control VR1 and fed to the amplification stage around IC1a. The gain is set at about 100 by resistors R2 and R5. The values of capacitors C2 and C4 respectively give a bit of bass and treble cut to the audio frequency being received, helping to reduce (although not totally eliminate) false triggering by any out-of-band noise on the signal.

From IC1a, the signal is a.c. coupled to the second amplification stage, around IC1b. Here the gain is set at around 10 by resistors R6 and R7. Resistors R3 and R4 provide a midway bias level to both stages.

The next stage extracts the Morse pulse "envelope" from the audio carrier signal. In the presence of pulses (DITs and DAHs), capacitor C6 is held charged via diode D1. When each pulse ceases, C6 discharges through preset VR2.

For as long as the voltage on the wiper of VR2 is above about 0·6V, transistor TR1 is turned on into full saturation, i.e. its collector voltage is at 0V. When each pulse ceases, the collector voltage returns high, to 5V (the power rail voltage).

Socket SK2 allows external (unmodulated) Morse pulses to be input in place of the audio signal (from a Morse key or computer, for example). Their amplitude should swing between 0V and greater than about 0·6V. The software automatically compensates for the signal inversion by TR1.

PIC PROCESSING

The output from TR1 is coupled to the Schmitt trigger input, RA4, of PIC microcontroller IC2. The software monitors the status of the input, from which information Morse pulse lengths are assessed.

The status of pin RA4 is copied by software (suitably re-inverted) to pin RA3. This allows demodulated pulses to be sent, via socket SK4, to other equipment, such as a PC which itself can decode signals into characters and display them on its screen. While developing the software, the author actually coupled two PCs to the PIC, one transmitting to it, the other receiving from it.

The pulsed signal from RA3 also drives an l.e.d., D3, via ballast resistor R13. This serves as an additional Morse code monitor. At lower transmission rates, the relative DIT and DAH lengths can be observed,

PANEL 2. COMMERCIAL MORSE DEMISE

The power and sophistication of modern communications systems, especially those via satellite, eventually eclipsed the need to use Morse code commercially and many radio stations worldwide have ceased Morse transmission and reception.

On January 1st 1999, the UK's 500kHz Coast Radio Station Service, for instance, ceased to maintain a distress watch and British Telecom MF Morse radio stations ceased all commercial Morse services. Other similar services also closed on the same day, some whose history goes back around a hundred years.

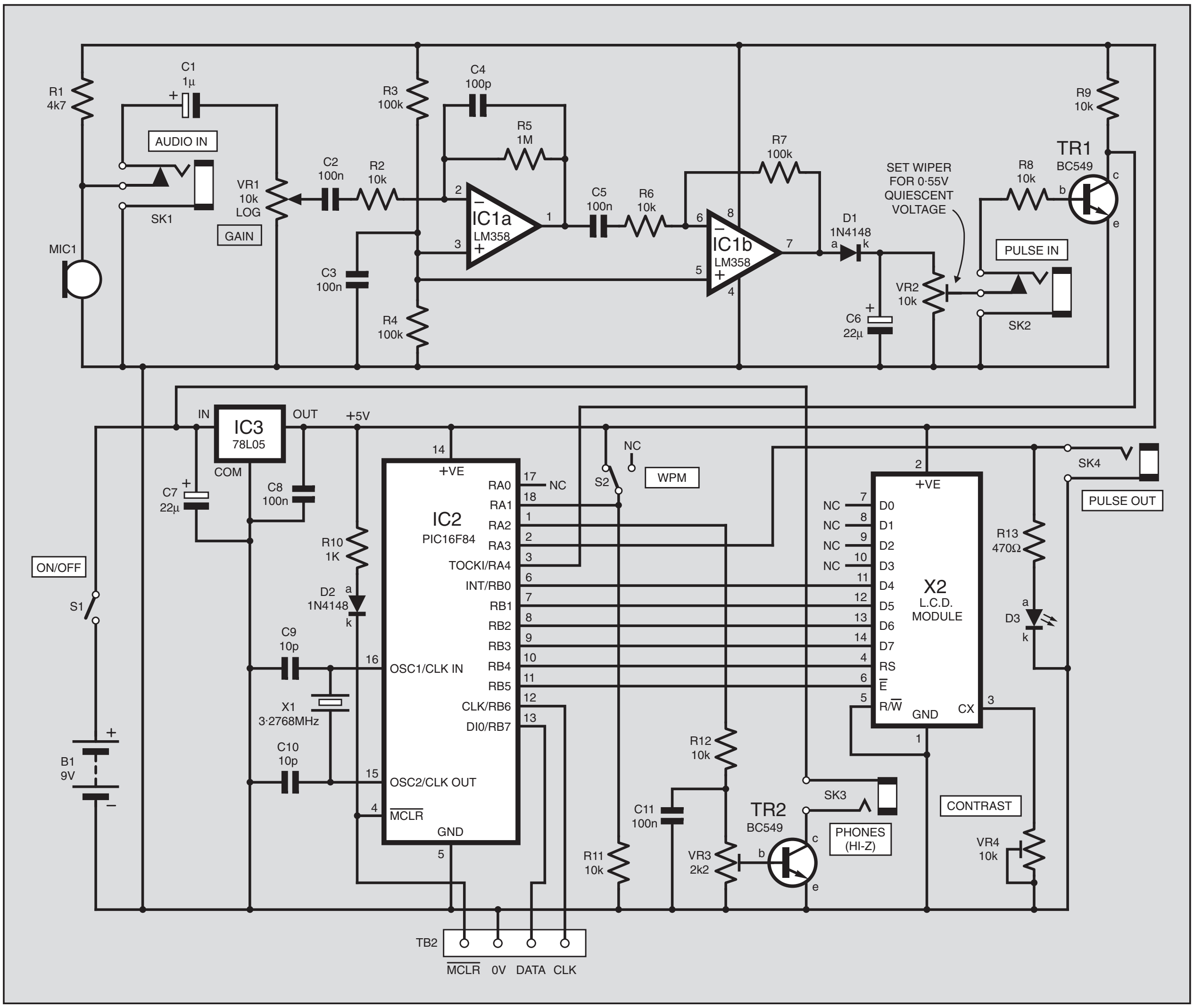


Fig.1. Complete circuit diagram for the EPE *Morse Code Reader.*

and even used as a visual source of Morse code.

Provision has been made for received Morse signals to be repeated as re-modulated audio tones (at roughly 1·3kHz) via high impedance headphones, connected via socket SK3. This facility is included as part of the unit's "learning" aspect, so that code transmissions simulated by the computer can be listened to and so test the listener's ability to mentally decode them.

The tones are output from pin RA2, sent via level control VR3 to transistor TR2, to which the headphones can be connected via socket SK3. It is stressed that high-impedance headphones (e.g. at least 40 ohms) *must* be used. The use of low impedance 'phones or a loudspeaker will kill the transistor (which has a rating of about 100mA).

Capacitor C11 smooths some of the harshness of the audio square wave – no attempt has been made to provide a "musical" tone!

In fact, using the software to generate the tone while carrying out other activities does not allow a precise audio frequency. Whilst the dominant frequency is about 1·3kHz, other underlying tones are just noticeable.

If you would prefer to listen to "cleaner" tones and you have an existing audio oscillator that can be keyed by voltage level changes, it could be driven via the pulse output at SK4.

MESSAGE DISPLAY

Visual display of the decoded Morse signals is via the 2-line 16-character (per line) alphanumeric l.c.d., X2. This is operated in standard 4-bit mode, with contrast setting performed by preset VR4.

Switch S2 causes the l.c.d. to show either two lines of message, or one line plus WPM data on the other.

In 2-line mode, the message is compiled on the lower line, the characters being placed consecutively from left to right across 16 "cells". On each 16th character the whole lower line is transferred to the top, the lower one cleared and message compilation starts again from the left. The message is not stored after being lost from the display.

In WPM mode, the WPM count is assessed every 60 seconds and output to the left of the upper line. The lower line shows the message as it progresses, with it being cleared after each 16 characters.

At the right of the upper line is displayed a sub-count of the words received since the last one-minute display occurred. It is updated after each batch of 16 characters has been received.

Typical l.c.d. screen in 2-line code display mode.

Typical l.c.d. screen showing WPM count on the top line.

OTHER ASPECTS

The PIC is run at 3·2768MHz, as set by crystal X1, and powered at +5V from regulator IC3. The unit itself may be powered, via IC3, at any d.c. voltage between about 7V and, say, 12V. Current consumption depends on the use of the headphones and their loudness. In quiescent mode consumption is about 7mA.

As usual with the author's PIC designs, provision for programming the PIC *in situ* has been made via connector TB2, whose connections, and those to the l.c.d., are in his "standard" order. *PIC Toolkit* Mk2 or Mk3 are suited to programming PICs *in situ* on board designs such as that used for this unit.

COMPONENTS

Resistors

See **SHOP TALK** page

R1	4k7
R2, R6, R8, R9, R11, R12	10k (6 off)
R3, R4, R7	100k (3 off)
R5	1M
R10	1k
R13	470Ω

All 0·25W 5% carbon film.

Potentiometers

VR1	10k rotary, log
VR2, VR4	10k min. preset, round (2 off)
VR3	2k2 min. preset, round

Capacitors

C1	1μ radial elect. 16V
C2, C3, C5, C8, C11	100n ceramic, 5mm pitch (5 off)
C4	100p ceramic, 5mm pitch
C6, C7	22μ radial elect. 16V (2 off)
C9, C10	10p ceramic, 5mm pitch (2 off)

Semiconductors

D1, D2	1N4148 signal diode
D3	red l.e.d.
TR1, TR2	BC549 *npn* general purpose small-signal transistor
IC1	LM358 dual op.amp
IC2	PIC16F84-4 microcontroller, preprogrammed, see text
IC3	78L05 100mA +5V voltage regulator

Miscellaneous

MIC1	min. electret microphone insert
S1, S2	min. s.p.d.t. (or s.p.s.t.) toggle switch (2 off)
SK1 to SK4	3·5mm *plastic* jack socket (4 off)
X1	3·2768MHz crystal
X2	2-line, 16-character (per line) alphanumeric l.c.d. module

Printed circuit board, available from the *EPE PCB Service*, code 368; plastic case, 150mm x 80mm x 50mm; 8-pin d.i.l. socket; 18-pin d.i.l. socket; panel-mounting l.e.d. clip; knob for VR1; PP3 battery and clip; pin header strips and sockets for TB1 and TB2 (see text); p.c.b. mounting supports (4 off); connecting wire; solder, etc.

Approx. Cost Guidance Only **£35** ***excluding battery***

CONSTRUCTION

Printed circuit board layout details for the EPE Morse Code Reader are shown in Fig.2, This board is available from the *EPE PCB Service*, code 368.

Use sockets for IC1 and IC2. Assemble in order of component size, preferably link wires first (noting that one lies under the socket for IC2).

Pin header strips were used in the prototype for connections to the TB1 and TB2 pins. Alternatively, 1mm terminal pins could be used.

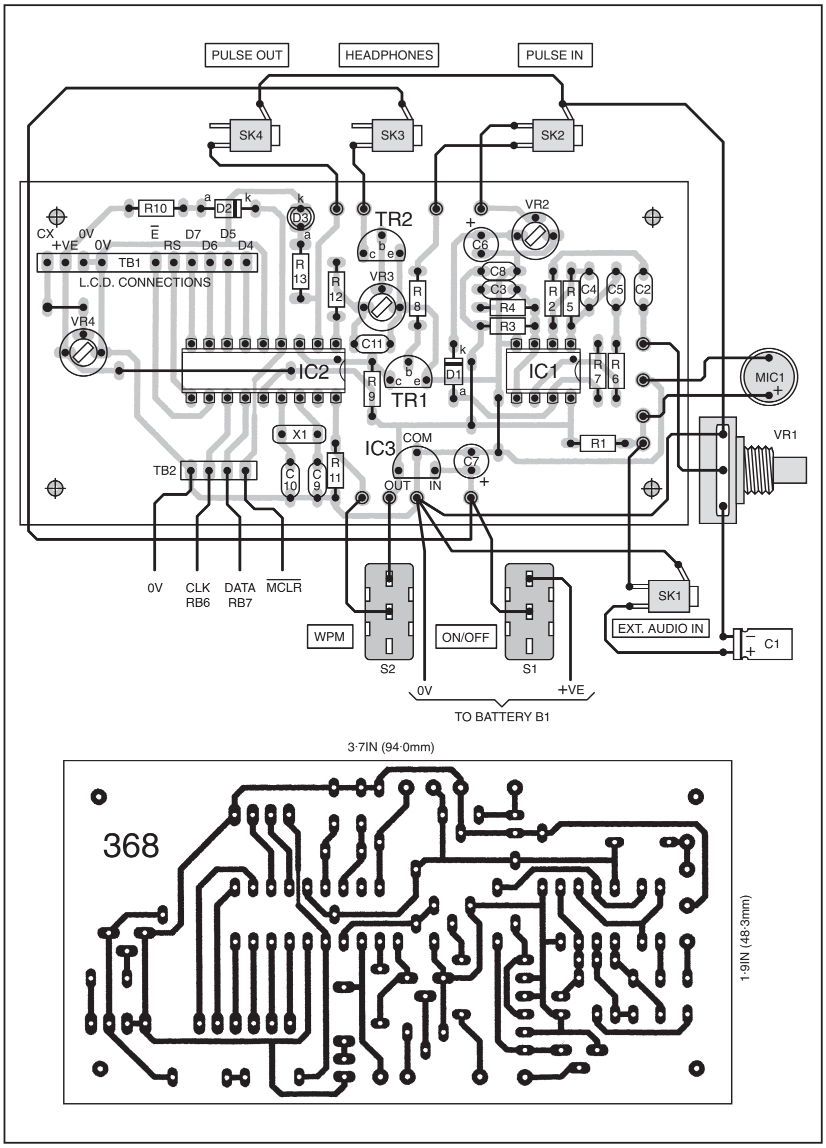


Fig.2. Component and full-size master track pattern layouts for the EPE *Morse Code Reader.*

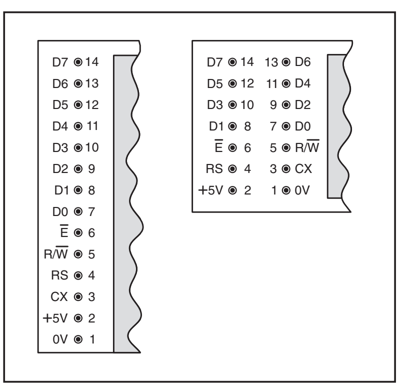


Fig.3. The two "standard" l.c.d. module pinout arrangements.

Before inserting IC1, IC2 or the l.c.d., check the correctness of your assembly and that +5V is present where indicated in the circuit diagram of Fig.1.

The unit was mounted in a plastic case, having cut a viewing slot to suit the l.c.d. screen, and holes drilled for switches, connectors, or direct external input/output wiring, etc.

A hole should also be drilled for the l.e.d. D3 (although this was not done with the prototype).

Sockets SK1 to SK4 should be *plastic* types (note that SK3 has its "common" terminal connected to the principal power line).

Typical pinout details for the l.c.d. module are shown in Fig.3.

COMPUTER INTERFACE

For learning purposes, the use of the PC-based Windows software for this design is ideal. Written in Visual Basic 6 (VB6) the software is completely standalone and does not require VB6 to be resident on your PC (but see later).

For output mode, the PC uses parallel port pin D0, and for input it uses pin ACK (see Fig.4).

Five Morse code output modes are available from the PC software:

- send text file in Morse
- send "Paris" as test word (reason given presently)
- send all characters for which a Morse code is known, either in alphanumeric or "binary" order

displaying timed counts in the box below the scales. The assessment is in relation to the number of DITs in the message multiplied by 1·2 (a factor quoted to the author by a Morse expert).

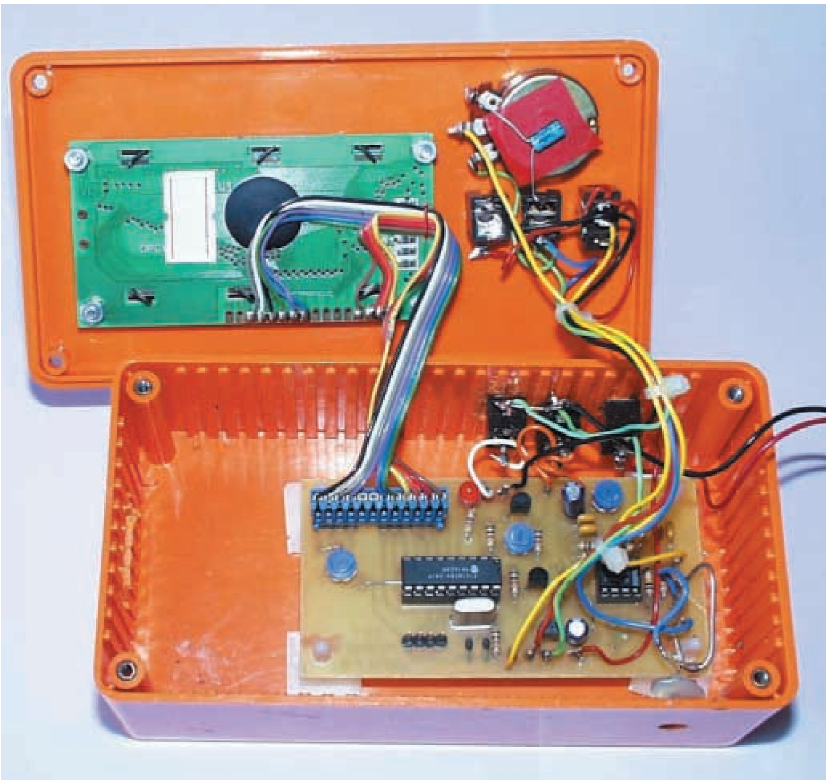
CODE SIMULATIONS

While browsing the web for Morse code info, it became apparent that learners of Morse can become tired of repeatedly listening to pre-recorded Morse test message tapes. The option to send *any message you like* has thus been included here.

It is intended that any Morse output from the PC is routed to the EPE Morse Code Reader unit. How it is then used is up to you. The most obvious use is to output an unfamiliar text file, listen to the Morse tones generated by the unit, and practice your decoding skills. The software is not linked to any audio interface installed on the PC.

To send a text file, click on Text File Directory to enter a typical Windows-style folder, path and file selector, through which any listed text file can be loaded for output as Morse code. Double-click on the file name chosen to select it and return to the main screen. The selected file name is confirmed at the bottom left of the screen. Only files having a **.TXT** extension can be accessed.

Then click on Send Test File to start transmission. Click Stop TX/RX to end it.



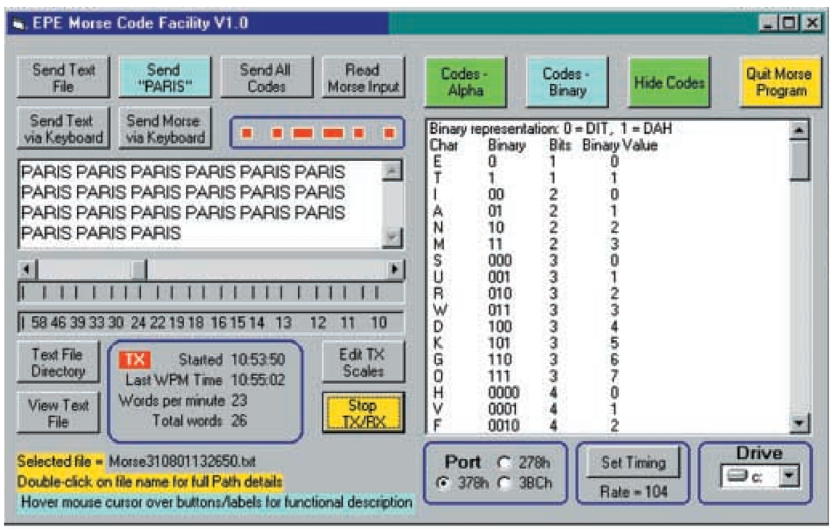
- Send characters directly keyed-in via keyboard
- Send Morse pulses in respect of duration of any keypress

The word *Paris* is that generally used to determine the words per minute rate (WPM) at which Morse code is transmitted. It supposedly represents the average DIT-DAH-letterspace-wordspace ratio encountered in a typical message transmission.

Clicking on the Send Paris button causes the software to repeatedly output this single word followed by a wordspace. Clicking on Stop TX/RX ends this mode (as it does for any transmission or reception mode). During any transmission, the message being processed is displayed in the left hand panel.

WPM RATES

A slider below the message panel sets the WPM rate at which any transmission is sent. The actual rate for a given setting is likely to vary between different PCs (the scale values shown below the slider are those used by the author). A facility has been provided to "tune" the scales to the rate actually produced by your PC for a given slider setting. Transmission of "Paris" is the mode to use for this.

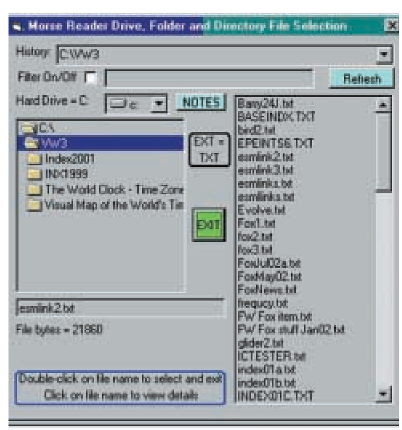


Above: Example of the main screen showing the Paris transmitted test message in the left hand text box and codes in "binary" order in the right hand panel.

Below: Typical example of the directory screen

Clicking on the button Edit TX Scales allows you to change scale legends via the keyboard. A Save TX Scales button is displayed while in this facility. Having changed the scales to your satisfaction, click this button to save the information to disk. It will be recalled next time you run the program.

Irrespective of the slider setting, the software makes a separate assessment of the WPM rate actually occurring,



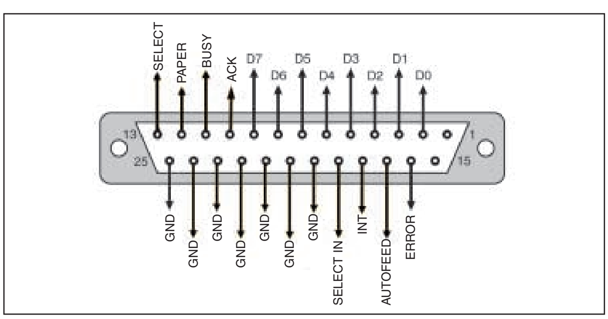


Fig.4. 25-way male D-type connector.

The chosen file can also be viewed via the PC's Notepad text editor by clicking on View Text File.

The Directory screen is a cut down version of that used in the author's *Toolkit TK3* PIC programming software (Oct-Nov '01). More details about using this option can be viewed via the Directory screen's NOTES button (there are several sub-options discussed).

ALL CODES MODE

Clicking Send All Codes outputs standard Morse codes in alphanumeric or binary order, depending on whether the Codes-Alpha or Codes-Binary button has been clicked (confirmed by it showing blue instead of green). The full code set for each selection is displayed in the right hand sub-window (it can be scrolled up or down for viewing).

The codes displayed can be hidden should you wish to by clicking Hide Codes.

KEYED TRANSMISSION

Clicking either Send Text via Keyboard or Send Morse via Keyboard, appropriately activates one of those two modes. In the keyed Text mode you should not allow your keying rate to exceed the WPM rate set by the slider (although the normal Windows keyboard buffer will take up the "slack" for a while).

Use almost any key you like to send Morse highs and lows as DITs and DAHs (but Num Lock will probably need to be On in order to use the right hand numeric keypad). The rate of keying is up to you and is not affected by the WPM slider.

The author is much too way out of Morse keying practice (by many decades!) to know how successful the keyboard DIT-DAHing might be, but it seemed an option that was worth adding in case it might be of any use.

FIRST USE

When first loaded, the PC software detects whether or not the program has been run before on the machine in use. If it has not, a set of internal routines are initiated which, among other things (relating to clearing any personal directory and other records accidentally left in by the author!), establishes a nominal base value used during code transmission.

Such values will vary from PC to PC. The value can also be set via the Set Timing button should you wish, the resulting value being displayed below this button. Note that it is simply a "looping" value used by the software and not a timing value in terms of specific units of time.

The assessment takes a couple of seconds, and it is normal for the value to differ slightly each time the assessment is made (due to the PC's own interrupts as mentioned earlier).

PORT SETTING

The software does not assess for itself the printer port register that your computer has been set to use. This is typically register 378h (hex), but could be 278h or 3BCh. At the bottom right of the screen is a PORT box with radio buttons which select the register to be used.

To check which one is correct, first leave the setting at the default of 378h and start sending "Paris" to the Morse Reader unit and observe its l.c.d. screen. If nothing appears on the l.c.d. within a few seconds, click on 278h. Again wait a while. If still nothing appears, try 3BCh.

If there is still no success, re-check the unit and its connections to the PC.

The selected port register value is automatically stored to disk for recall next time the program is run.

RELOCATION

It is believed that the PC software is totally relocatable in terms of which drive or folder it is run from. Normally, it is likely that you will wish to run it from your C-drive. Alternative drive letters (including a partition) may be selected via the Drive option at the bottom right of the screen. This selection is also stored to disk for future recall.

Do not use a floppy or CD-drive from which to run the software. It is preferable to remain with the standard C-drive if possible.

ERROR TRAPPING

The PC software has been subjected to extensive "error-mode" checking and includes various error-trapping routines. If something unexpected occurs in an error-trapped routine, you will be advised so via a separate Error Message screen.

However, if something occurs for which the author has not provided an answer or interception, let him know via the Editorial office (not via the *Chat Zone* as he does not necessarily access this on a regular basis and your message might be missed).

PROGRAM EXIT

Finally, to exit the PC Morse software click on the Quit Morse Program button, which will fully close it. If you use the top-right Windows X button, the program may only become "hidden", remaining active in the Desktop screen's lower toolbar.

It is worth exploring your Morse screen with the mouse cursor. There are various notes that appear when it hovers briefly over buttons and labels.

MORSE CODE DATA

Should you wish to add a new Morse code item to those known to the PC software (author!), you can do so by accessing file **MorseCode.txt** held in the main Morse folder. Double-click on the file to open it through Notepad. It can now be amended, and resaved as the same name and file type.

Do not edit the file via a wordprocessing program since this might add format codes which would affect the correct use of the file by the Morse software.

SOFTWARE

Software for the PIC unit and PC interface is available on 3·5-inch disk from the Editorial office (a small handling charge applies) or downloaded free from our ftp site. The latter is accessible via the top of the title page of the main *EPE* web site at **www.epemag.wimborne.co.uk**. Click on "FTP Site (downloads)", then in turn on PUB and PICS, in which page the files are in the folder named MORSE.

More details of both options are given on this month's *Shoptalk* page, plus information on obtaining pre-programmed PICs.

The PIC program (ASM) was written in TASM, although the run-time assembly is supplied both as a TASM OBJ file and an MPASM HEX file (the latter has configuration values embedded in it). Users of the TASM OBJ file should configure their PIC for crystal XT, WDT off, POR on.

Regarding the PC interface, if you have Visual Basic 6 already installed on your machine you only need to use files **Morse.exe**, **INPOUT.DLL** and **Morse Code.txt**. Copy them into a new folder named MORSE (or any other of your choosing).

If you do not have VB6, you need three other files, **comdlg32.ocx**, **Mscomctl.ocx** and **Msvbvm60.dll**, held on our 3·5-inch disk named Interface Disk 1, and in the Interface folder on the ftp site (they are also included with the *Toolkit TK3* software). These files must be copied into the same folder as the other three files.

MORSE WEB SITES

There are too many web sites devoted to Morse code for them to be listed here. However, do as the author did (and mentioned earlier), search via **www.google.com** (an excellent search engine).

Those who wish to know more about becoming an amateur radio operator in the UK should contact the Radio Society of Great Britain (RSGB). They will also advise details of their Morse test transmissions, courses and exam requirements. RSGB, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE. Web: www.rsgb.org.

Books by our *New Technology* author, Ian Poole, also provide information about amateur radio. Browse **lineone.net/~ian_poole/books**.

Morsum Magnificat is a bi-monthly magazine that has been around since 1983 and "is for all Morse enthusiasts, amateur or professional, active or retired. It brings together material which would otherwise be lost to posterity, providing an invaluable source of interest, reference and record relating to the traditions and practice of Morse".

Information about *MM* can be obtained through *Morsum Magnificat*, The Poplars, Wistanswick, Market Drayton, Shropshire TF9 2BA. Tel: 01630 638306. Fax: 01630 638051. E-mail: zyg@MorseMag.com. Web: www.MorseMag.com. (It can also be found at www.morsemag.com.) □

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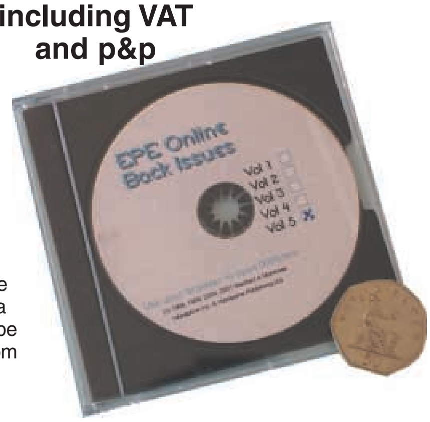

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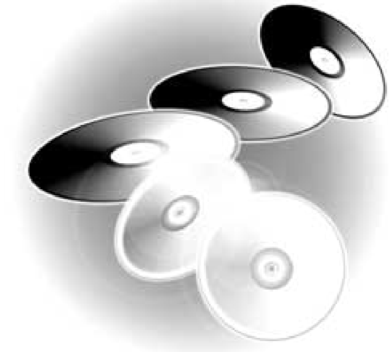
VINYL TO CD PREAMPLIFIER



TERRY de VAUX-BALBIRNIE

Clean up those old records, dust down that turntable and let's get burning!

DO YOU have a collection of old vinyl records? If so, you might wish to transfer them to CDs. By doing this, you will preserve their value because you will only need to play them once.

It may even be possible to enhance the sound by removing some of the background noise and clicks which are found on worn recordings. If you have a CD player in your car or own a portable unit, you will also be able to play your work "on the move".

SYSTEM REQUIREMENTS

To transfer a recording to CD, you need a computer with a Compact Disc writer installed. Many new machines, of course, already have one of these. If yours is not so equipped, you will find that fitting a CD "burner" module is inexpensive and straightforward.

You do not even need a particularly modern machine. A Pentium 133MHz PC may suffice but a new up-to-date machine will be much quicker (that is, produce a CD at the higher speeds allowed by the writer). Before purchasing any hardware, it is important to check compatibility with the supplier/manufacturer.

To record sound files on to the hard drive before transferring them to a CD will require quite a lot of spare capacity. If your drive is almost full, you will need to back up files in order to clear sufficient space. To record stereo tracks in 16-bit resolution at 44·1kHz (CD quality) you will need some 600MB for one hour of work and you could run into trouble if you do not have at least 800MB available.

METHODOLOGY

It is not a good idea to link the record deck to the computer sound card *direct* by plugging it into the microphone input. Some people have done this thinking, quite correctly, that a magnetic cartridge provides a low-level output comparable with that of a dynamic microphone. Although this may work, the results will be very disappointing. This is because no *equalisation* has been applied to the signal. It will be found that the copy recording is deficient in bass (low frequencies) but have excessive treble (high frequency content). In other words, it will sound very "tinny". More will be said about equalisation presently.

A better method would be to use an existing hi-fi amplifier. The record deck would be plugged into its "Phono" input and a Line (high level) output obtained at the back (the one used for tape recording). This would be connected to the line input on the sound card using a piece of twin-screened wire fitted with the appropriate connectors. The phono connection would provide the necessary equalisation.

Unfortunately, many modern amplifiers make no provision for playing "old fashioned" vinyl discs. You may therefore find that it has no phono input. Even if you do have a suitable amplifier, it may need a long connecting lead to reach the computer station and this could result in hum pick-up and degraded performance.

OVERVIEW

The circuit described here is a small battery-operated stereo preamplifier which provides equalisation and boosts the output of a magnetic cartridge to line-level. There are also Scratch and Rumble filter push-button switches. These may be used to reduce the effects of surface clicks and low-frequency motor or turntable noise respectively.

As well as being useful for making CDs, the preamplifier will be found handy by enthusiasts who simply wish to play their vinyl records using a hi-fi amplifier that does not have a phono input. Some readers may even use it for tape or Mini Disc work or for making MP3 files to be sent over the Internet.

In operation, the circuit requires some 40mA and the four AA size cells housed internally will provide up to fifty hours of service. A front panel mounted l.e.d. indicator requires some 15mA so, if the user can be trusted to switch the unit off after use, the l.e.d. may be omitted. This would give a significant increase in battery life. For extended periods of use, a larger battery could be placed externally.

This unit must not be powered using a mains-derived low-voltage supply (such as a plug-in adaptor).

MORE EQUAL THAN OTHERS

Returning to the topic of equalisation, this must be applied if analogue recordings are to be reproduced with any degree of

fidelity. To understand why this is necessary, you need to know something about the recording process.

Imagine the sound has three "bands" comprising the *low, intermediate* and *high* frequency content. When the groove was cut in the master disc, the low frequency part was reduced in level (volume) while the high frequencies were increased. Only the intermediate band was left unchanged.

Leaving the low frequencies as they were in the original sound would have required more violent movements of the groove cutter (that is, heavier modulation). This would have produced a wider groove and a consequent reduction in available playing time. Also, the playing stylus might have difficulty following such a groove and it may tend to jump out. By reducing the level of the low-frequency sound, it is possible to obtain a uniform groove width and a longer playing time.

Equalisation is the process by which the high and low frequency content from the cartridge are restored to their original state and, in theory, should be an exact mirror of that used during recording. Note that by restoring the high frequencies, the surface noise present during playback (which is made up chiefly of high frequencies) is reduced. It thus provides a simple means of noise reduction.

MAINTAINING STANDARDS

Unfortunately, different equalisation standards have existed regarding the values of the cut-off frequencies defining the low, intermediate and high bands and also the degree of "cut" or "boost". The same circuit will therefore not provide perfect results with all records.

However, most vinyl discs produced since the 60s have followed the RIAA (*Recording Industry Association of America*) standard. In practice, an equaliser designed for this standard will also provide good results when applied to recordings using a different one (*American Standard Record* and *British Microgroove* format). It should also be suitable for 78s.

Practical equalisation circuits can range from the simple (which provide only a coarse correction) to the very complex. This circuit lies somewhere near the middle of the range and provides good results without special adjustment.

The graph shown in Fig.1 illustrates the ideal (theoretical) RIAA equalisation compared with that provided by this circuit. Note that this is for illustration only and is not drawn to scale.

The section to the left-hand side labelled "A" provides a "roll-off" of frequencies below some 10Hz. This reduces the "rumble" that is transmitted from the motor or turntable bearing to the cartridge through the turntable. This is much more pronounced with a cheap unit and without such a "cut" would be accentuated due to the low-frequency boost made during equalisation.

Before proceeding to construct this circuit, check that you have a good quality record deck available. This must be fitted with a *magnetic* cartridge (not a ceramic one). If you wish to transfer 78 r.p.m. records, make sure your turntable will operate at this speed (many are designed for 33/45 only) also that it is fitted with the correct type of stylus.

CIRCUIT DETAILS

The full circuit diagram for the Vinyl To CD Preamplifier is shown in Fig.2. This is built around three identical dual low-noise operational amplifiers (op.amps) – IC1a/IC1b, IC2a/IC2b and IC3a/IC3b.

Equalisation of left and right channels is centred around IC1 and IC2 respectively, while IC3 is a "straight" amplifier which boosts both channels to line level.

It is only necessary to describe the action of one channel (the left-hand one) since the other is the same. Note that the component numbering for the right-hand channel is prefixed with a "one hundred". Thus, R2 (left) corresponds with "R102" (right). Components which are common to both channels, the i.c.s, switches and input/output sockets are numbered as if they belonged to the left channel.

NON-INVERTING AMPLIFIER

The first section of the circuit is a non-inverting amplifier IC1a. The signal obtained from the input cartridge (left-hand channel) at SK1 is applied to the non-inverting input, pin 3, via capacitor C2 (or C1 and C2 in parallel if Rumble switch S1a contacts are closed).

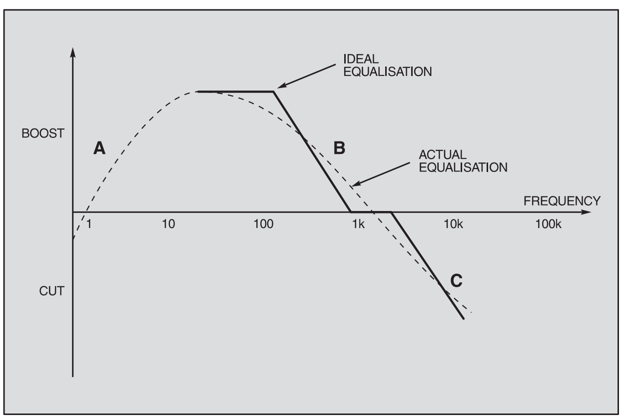


Fig.1. Equalisation graph (not to scale): a) roll-off; b) fall-off and c) high frequency filtering.

This, in conjunction with fixed resistor R3, determine the anti-rumble characteristics of the circuit (the roll-off below 10Hz labelled "A" in Fig. 1). Resistor R3 also sets the input impedance making it suitable for a standard magnetic cartridge.

Anti-rumble processing comes about because the impedance of capacitor C2 rises as the frequency falls. High frequency signals will then flow more easily through resistor R3 and hence through capacitor C3 (which has a relatively high value and therefore negligible impedance at these frequencies) to 0V.

It is, therefore, the higher-frequency signals which develop a greater voltage at IC1a pin 3. In other words, the low frequencies tend to be filtered out.

With the Rumble switch contacts closed, the pair of capacitors C1 and C2 give the same effect as a single unit having a larger value. This decreases the overall impedance and the circuit rolls off at a lower frequency.

OPERATING CHARACTERISTICS

The output of IC1a at pin 1 is connected to its inverting input (pin 2) through the parallel arrangement of resistor R5 and capacitor C4. This works in conjunction with resistor R4 to set the gain.

The other end of R4 is connected to the mid-point of a potential divider consisting of equal-value resistors R1 and R2. This sets a d.c. voltage nominally equal to one-half that of the supply – that is, 3V. This provides a "zero" reference so that the a.c. input signal will rise and fall with respect to it.

If the reference was a true 0V (the voltage of the 0V supply line), the negative half-cycles of the wave would not be amplified. This is because the output voltage cannot fall below 0V. As it is, the output signal will swing above and below the 3V level.

Ignoring the effect of capacitor C4 for the moment, the gain of this section is approximately eight times. However, with C4 in place, the impedance of the feedback loop will fall as the frequency rises. This reduces the gain at higher frequencies and provides the "fall-off" characteristic shown by Fig.1 section "B".

Section IC1b of the circuit is configured as a unity-gain amplifier (buffer). The signal from IC1a output, at pin 1, passes through resistor R7 (or R6 connected in parallel with it when Scratch switch contacts S2a are closed) to IC1b's non-inverting input at pin 5.

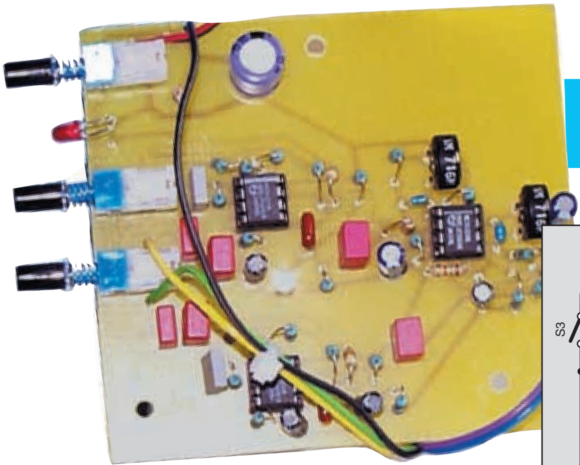
High frequency signals now flow more easily through capacitor C5 (due to its reduced impedance) and hence to a further "false zero" derived from the potential divider made up of resistors R8 and R9. The voltage appearing at IC1b pin 5 will therefore be less than with higher frequencies. The higher frequencies therefore tend to be filtered out (shown by section "C" in Fig.1).

SCRATCH MY BACK

With Scratch switch S2a contacts closed, resistors R6 and R7 are placed in parallel and provide near-RIAA high-frequency attenuation. With the switch contacts open, resistor R7 alone provides a more dramatic cut-off and provides the "scratch reduction" effect. These values may be experimented with or a "tone control" could be fitted to give a continuously variable effect. More will be said about this later.

The output from IC1b, pin 7, is now equalised but still at a low level. The next section, centred around IC3a, is an amplifier used in inverting mode. This boosts the signal by a large factor making it suitable to drive the line input of a sound card or external power amplifier.

Capacitor C7 allows the output signal from IC1b pin 7 to pass with little loss (due to its relatively low impedance at



VINYL TO CD PREAMPLIFIER

COMPONENTS

See SHOP TALK page

Resistors
R1, R101,
R2, R102,
R8, R108,
R9, R109 2k2 (8 off)
R3, R103,
R4, R104
R10, R110,
R11, R111 47k (8 off)

R5, R105,
R6, R106 330k (4 off)
R7, R107 120k (2 off)
R12, R112 15k (2 off)
R13, R113 1M5 (2 off)
R14 270Ω
All resistors 0·6W 1% metal film.

Potentiometers
VR1, VR101 1M min. enclosed carbon preset, vert. (2 off).

Capacitors
C1, C101 470n polyester film (2 off)
C2, C102 330n polyester film (2 off)
C3, C103,
C6, C106 22µ min. radial elect. 16V
C8, C108 (6 off)
C4, C104 10n polyester film (2 off)
C5, C105 2n2 polyester film (2 off)
C7, C107 1µ polyester film (2 off)
C9, C109 10pF ceramic (2 off)
C10, C110 10µ min. radial elect. 16V (2 off)
C11 220µ min. radial elect. 16V

Semiconductors
D1 3mm red l.e.d.
IC1 to IC3 NE5532AN dual low-noise op.amp (3 off)

Miscellaneous
S1 to S3 d.p.d.t. interlocking push-button switch – see text (3 off)
B1 6V battery pack (4 x AA alkaline cells)
SK1 to SK4 phono socket, single hole, panel mounting (see text) (4 off)

Printed circuit board available from the *EPE PCB Service*, code 366; 8-pin d.i.l. i.c. socket (3 off); aluminium instrument case, size 150mm x 100mm x 75mm; battery holder and connector; 3mm l.e.d. clip; screened cable; multistrand connecting wire; solder, etc.

Approx. Cost Guidance Only **£24** *excl. batts. & case*

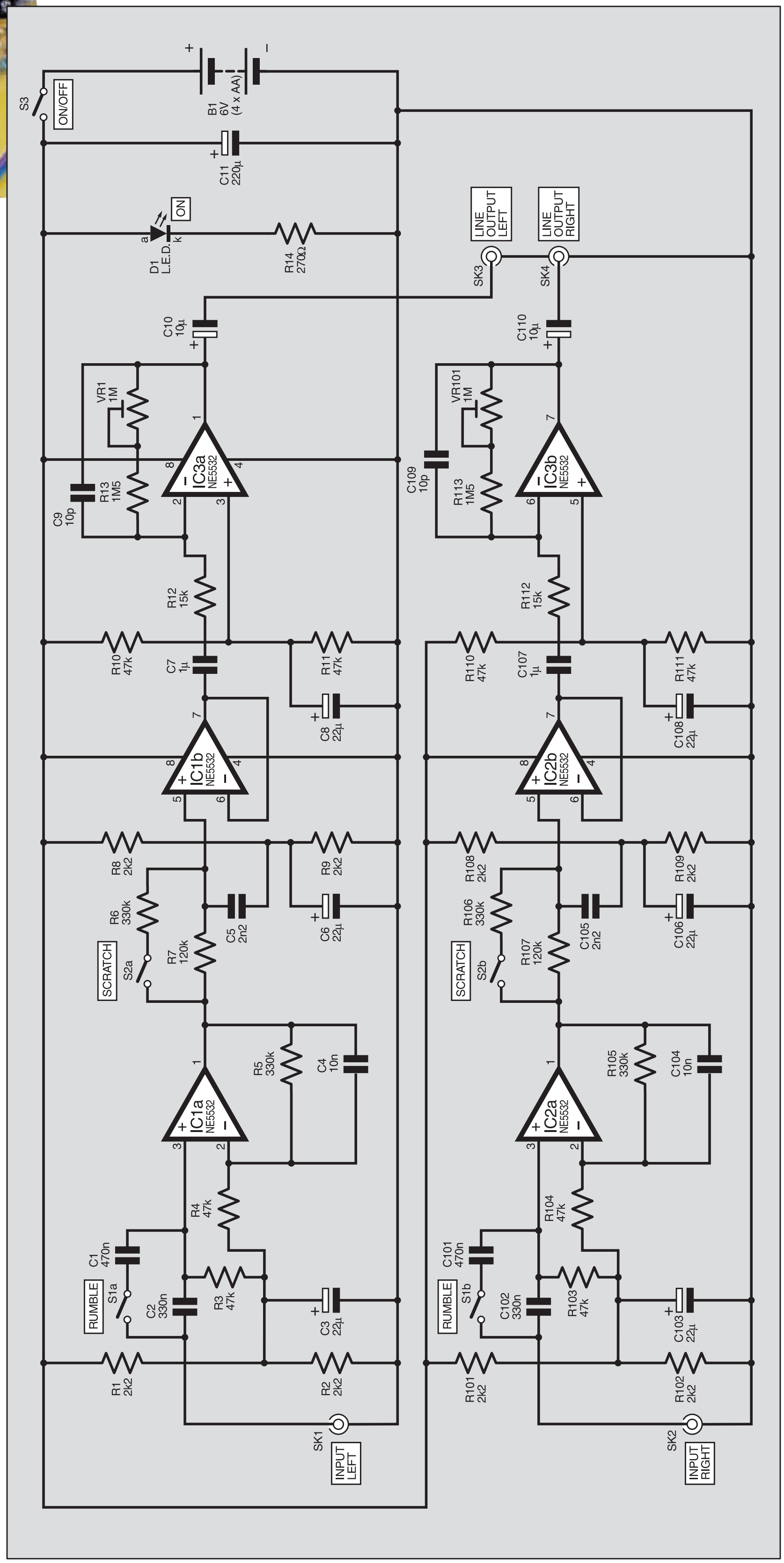


Fig.1. Complete circuit diagram for the Vinyl To CD Preamplifier.

audio frequencies) through resistor R12 and hence to IC3a inverting input at pin 2. Ignoring capacitor C9 for the moment, fixed resistor R13 connected in series with preset potentiometer VR1 provides negative feedback and, in conjunction with R12, sets the gain.

This will be some 170 times with VR1 set to its maximum value and 100 times at minimum. Preset VR1 will be adjusted at the end to provide a suitable output for the particular cartridge being used.

The value of resistor R13 could be increased to provide a greater gain if this is shown to be necessary at the testing stage. By adjusting preset VR1 in conjunction with its opposite number in the other channel (VR101), the circuit will also be "balanced" to provide equal outputs for both channels.

PROMOTING STABILITY

Returning to capacitor C9 which appears in IC3a feedback loop, its small value provides an extremely high impedance at audio frequencies. It therefore normally has negligible effect.

However, if radio-frequency signals happen to be picked up by the circuit, the impedance of C9 will be low. This will lower the impedance of the feedback loop and reduce the gain at these frequencies. This prevents instability.

The output signal finally passes from IC3a pin 1, via capacitor C10, to Line Output socket, SK3 (Left channel).

CONSTRUCTION

Construction of the Vinyl To CD Preamplifier is based on a single-sided printed circuit board. This board is available from the *EPE PCB Service,* code 366. The topside component layout and actual size underside copper foil master pattern are shown in Fig.3.

Commence construction by drilling the three mounting holes as indicated. Solder the spring-loaded, pushbutton switches in position. If the specified type is not available, use toggle or slide units and hard-wire these to the appropriate points on the p.c.b. at the end of construction. Next, solder in position the three i.c. sockets.

Follow with all resistors, preset potentiometers and capacitors – taking particular care over the polarity of the electrolytics. Solder the battery connector to the +6V and 0V points on the p.c.b., again, taking care over their polarity. Adjust presets VR1 and VR101 to approximately mid-track position to provide a medium degree of gain for each channel.

BOXING UP

Note that this circuit must be housed in a METAL box to provide adequate screening against hum pick-up.

Decide on a suitable layout for the internal components. Measure the positions of the switches and l.e.d. on the p.c.b. Mark these on the front panel of the box at the half-height level and drill them through. Mark and drill the p.c.b. mounting holes also those for the battery holder and the input and output sockets.

Cut plastic stand-off insulators to the correct length so that, when the p.c.b. is in position, the switch buttons will pass through their holes with a little clearance. Secure the p.c.b. and make sure the switches operate freely.

Attach the battery holder and the input and output sockets. If these are of the specified type, you will need to scrape away the paint on the inside surface of the box to allow the outer ("sleeve") connections to make good metallic contact with the case.

Attach one of the solder tags supplied with the sockets under the fixing nut of one of them. This will be used to "earth" the "0V" wire leading from the circuit board.

If you are using sockets of the fully-insulated type rather than the specified pattern, the sleeve connection of *each* must be connected to the case (0V) using a separate solder tag.

Referring to Fig.4 and photographs, complete the internal wiring. Take care that left and right inputs and outputs maintain their identity during the wiring process (that is, they do not become interchanged). Set all switches to the "out" position, insert the batteries and attach the lid of the case.

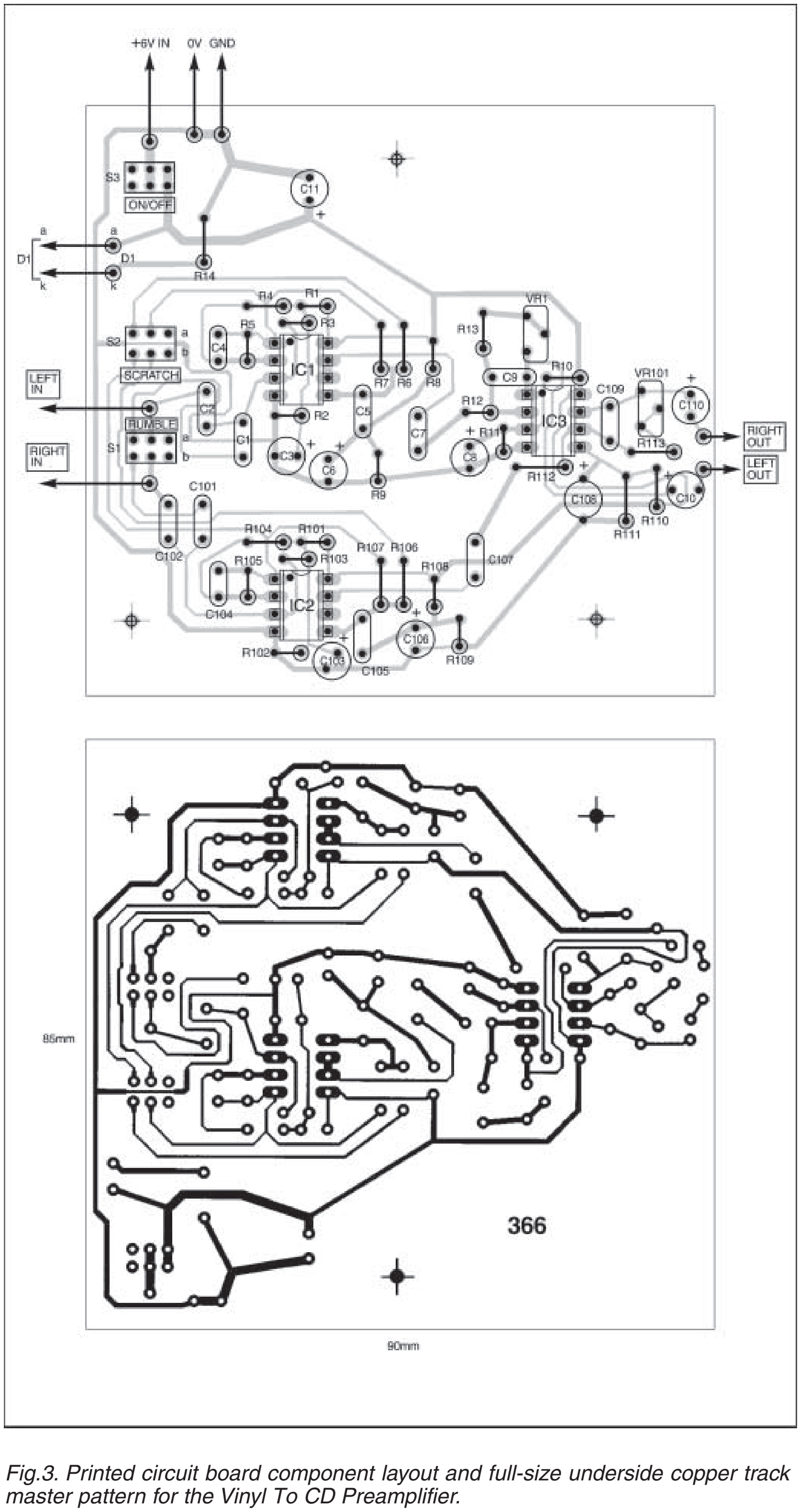


Fig.3. Printed circuit board component layout and full-size underside copper track master pattern for the Vinyl To CD Preamplifier.

TESTING

Unless the stylus on the record deck is known to have given very little service, renew it. Styli cost very little compared with that of your record collection. Also, a new stylus will give better results. If you are going to transfer 78s you *must* have the correct stylus fitted – *do not use one made for 33s/45s.*

It would be useful to have the turntable manual available to help make optimum stylus pressure and anti-skid adjustments. Sometimes a slightly greater pressure than normal will give better results. Although this wears the record more quickly it may be worthwhile since the record need only be played once.

For initial testing, connect the output of the preamplifier to the line input of a hi-fi amplifier using twin-screened cable fitted with the appropriate connectors. Do *not* connect it to the computer sound card at this stage.

Connect the turntable to the preamplifier input sockets. If possible, use a valueless record to make initial tests. Turn the Volume control on the amplifier to minimum and switch on both units. Check that the front panel l.e.d. operates.

It may be found convenient to use headphones to monitor the sound. Start playing the record and gradually increase the amplifier's volume control. The music should be clearly heard. Compare the volume with that playing similar music from a commercial CD.

If the levels are not similar, adjust VR1 and VR101 so that they are. If one channel is quieter than the other, adjust presets VR1 or VR101 as appropriate to bring the weaker channel to the level of the stronger one. This procedure ensures that the output is at line level and balanced between the channels.

Check the effects of the Scratch and Rumble switches. The rumble effect is very subtle and may not be noticed. Note that, as described, pressing the switches *in* provides the anti-scratch and anti-rumble effects.

SUBJECT FOR EXPERIMENT

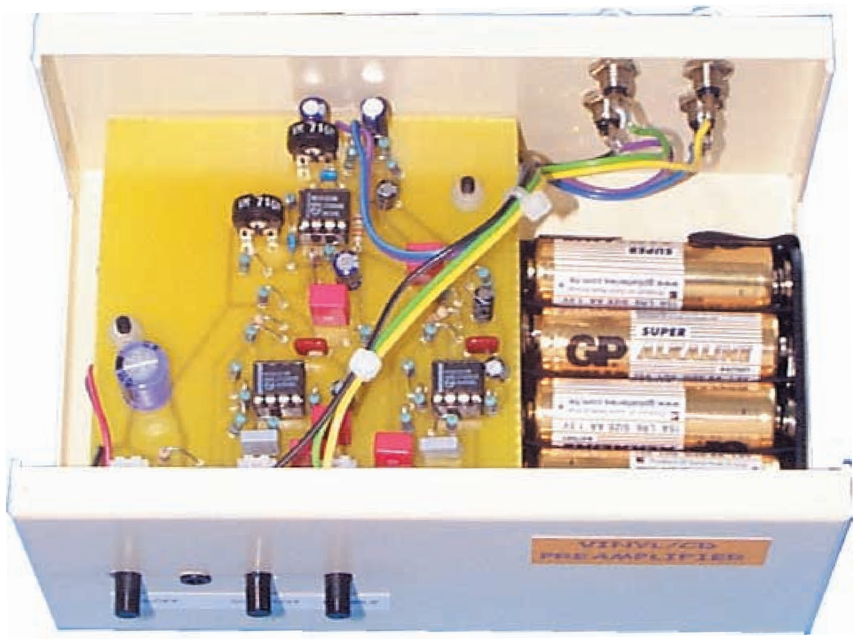
The frequency balance and anti-scratch effects could be altered by changing the value of resistors R6/R7 and R106/R107. By increasing the appropriate resistor values slightly, the high-frequency response will be "cut" and vice versa. Beware – small changes make a lot of difference!

An alternative method would be to replace resistors R7/R107 with a dual-ganged, panel-mounted, potentiometer (stereo). This would allow for continuous variation and switch S2 could then be ignored.

MAKING TRACKS

When setting up the equipment to make CDs, the turntable should not be placed on the same surface as the computer (otherwise you could introduce hum due to vibration being transferred to the cartridge from the computer). Check that the turntable is "true" using a spirit level.

Connect the preamplifier output to the line input of the PC sound card using twin-screened wire. Check that Left and Right channels are connected correctly.



Layout of components inside the metal case.

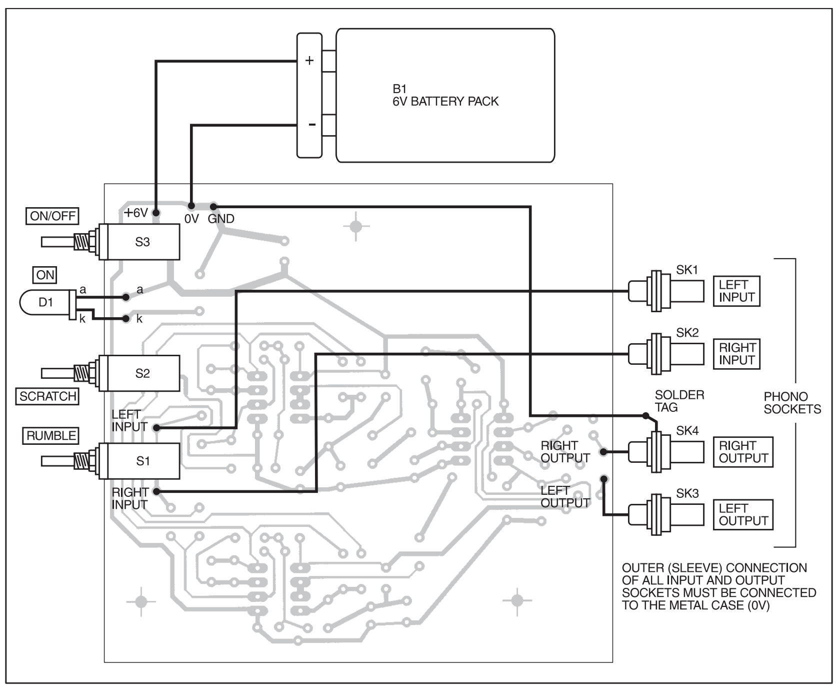


Fig.4. Interwiring details from the printed circuit board to the rear panel mounted input and output phono sockets.

Before making a recording, clean the surface of the disc using a proprietary anti-static cleaner. If it is very dirty, it will need special treatment to remove the debris which will have become deeply embedded in the groove. You could try playing it once or twice in an attempt to allow the stylus itself to remove the contamination.

STYLUS CHECKS

Check the stylus *after every playing* for any build-up of fluff and dirt. Leaving this will spoil the high-frequency response and also tend to cause the stylus to jump out of the groove. Use a proprietary stylus cleaning kit (a fine brush and cleaning fluid). Styluses are easily damaged so follow the instructions and work carefully.

MAKING A RECORDING

Refer to your CD recording software instructions to make optimum sound level settings and make some tests using the old record. For your final recordings, you will probably be able to observe the file oscilloscope-style. It is then possible to remove the heaviest clicks by highlighting and deleting them.

However, this must be done with great care. Some CD recording software allows for sophisticated restoration work to be undertaken. Automatic click suppression can be a problem because many sections of the intended waveform are click-like.

One final point – do not use the scratch filter unless the result sounds better. This is because it gives a markedly "dull" effect. ☐

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L.C.D. CLOCK MODULE with details of other uses. Order Ref: 2P307.
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POWERFUL MAINS MOTOR with 4in. spindle. Order Ref: 2P262.
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BALANCE ASSEMBLY KITS. Japanese made, when assembled ideal for chemical experiments, complete with tweezers and 6 weights 0·5 to 5 grams. Price £2. Order Ref: 2P44.
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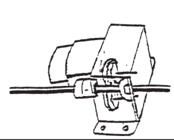

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John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

WIN A DIGITAL MULTIMETER

A $3\frac{1}{2}$ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

SHOCK HORROR TALE!

Dear EPE,

I was re-reading some old *EPE* issues while waiting for the latest to turn up here in New Zealand (I don't suppose you could print *EPE* every week, could you?), and something Alan Winstanley wrote in *Circuit Surgery* of Sept '00 made me laugh out loud. I hasten to say I have the greatest respect for Alan's intellect which shines through everything he does, but I was reminded that there is sometimes a second, more amusing explanation for a set of symptoms.

A reader had queried Alan about "worrying" electric shocks from his dishwasher, and yet his RCD (residual current device) had not tripped the power off, and the RCD "checked out OK". Alan theorized a possible insulation fault but gave the excellent advice to get the dishwasher looked at by a professional.

The following story from my time as an electronic repairman shows how a working RCD might not trip even though the machine it is attached to is giving you electric shocks.

Some years ago I quickly attended a similar "fault" in an old, all-metal franking machine (stamps postage on envelopes) which had been relocated in an old office building and, while it was running well, had been giving electric shocks to everybody since the relocation "even when it was switched off". I believe the NZ power distribution system is the same as UK, 230V a.c., 50Hz, multiple earthed neutral, so on the way to the fault I was mentally going over things like earth wire broken off in the old machine, wiring faults and errors in the building, etc.

The ladies who used the machine were in some fear of their lives, and I had firmly advised them over the phone that this fear was well-grounded (is that a pun?). When I arrived onsite they were at first rather put out when they saw me dash in, wave my meter about the machine, glance around the room and burst out laughing.

What I really did was to check the machine competently, and drew the conclusion that when they walked over the nice new carpet in their nice refurbished office in their pretty feminine artificial "leather" shoes to the machine, all those thousands of volts of static electricity they had built up found a ready path to ground through the well-earthed machine! And that was it.

After my careful and sympathetic explanation to the ladies about how to minimise static buildup, and how it wasn't endangering their lives anyway, they ruefully saw the reason for my amusement, but still didn't want to touch the machine. In the end I suggested they leave the office scissors (metal) near the machine, they could pick up the scissors and, holding them firmly, touch the machine with the scissors first, thereby discharging themselves with a mighty *crack!* of spark and not feel a thing.

And that would be one way that *EPE* readers could get even severely-felt electric shocks "from" a machine and yet the machine's fully operational RCD wouldn't trip. Having said that, I very strongly advise people not to assume that electric shocks from machinery are just harmless "static". Get it checked or plan your funeral, electricity is a good servant but a bad master!

Stan Hood,
Christchurch, New Zealand

Reminds me of a situation in my late school years. While showering in the sports changing room, I frequently felt tingles in my hand when lightly coming into contact with the metal shower tap. For weeks the school authorities would not believe me when I said that the tingling was due to electricity being present on the water piping.

Eventually the Electricity Board was called in – yes indeed, there was an electrical problem, affecting the adequate earthing of that part of the building. A lot of digging in the road outside was required before the fault was found and cured! I would not be telling the tale had the current flow been more severe.

PIC ALARM

Dear EPE,

I've been building your *PIC Controlled Intruder Alarm* (Apr '02) – great application! It seems, though, that you can only arm the alarm when the entry zone is set-up to be normally-open, is this so?

In your article you suggest feedback would be welcome on the use of the RB4 interrupt for the panic switch. I have linked pins of the S3 connector but can still trigger the panic event by generating mains noise, even pulling the plug out and switching to battery power sometimes generates the event. I'm planning to add mains suppression etc.

Mark Jones,
via email

Feedback is always welcome Mark, thanks. The entry zone restriction was not intentional, but in practice I have never encountered a situation where entering the main door zone could require a choice between normally-open and normally-closed contacts.

HOME SECURITY

Dear EPE,

I am currently doing my final year project on a home security system which involves a 4 × 3 matrix keypad, PIR sensor, magnetic switch and glass break detector. I'm using a PIC16F84 and PICBasic to write the software. Can you please give me some advice?

Brendon, Malaysia, by email

Sorry to disappoint you Brendon, but we cannot give specific advice for reader's own designs, but you might find my PIC Controlled Intruder Alarm *of April '02 of interest. That uses a matrixed keypad.*

8051 FREEWARE

Dear EPE,

I know that most of your projects that use microcontrollers are based around PIC devices, but I just want to let any of your readers who use the 8051 microcontroller, or its many derivatives, know about a very good freeware open source ANSI compliant optimising C compiler which I have been using for a few months, now called SDCC. It's available for download from **sdcc.sourceforge.net**.

There are several discussion forums for its users also on the same site. It can also be targeted at Z80, Gameboy Z80, AVR and PIC14x microcontrollers, and comes with a freeware 8051 software simulator.

Keep up the good work on your magazine, I have been a reader since I was a schoolboy hobbyist.

Jez Smith, by email

Thanks Jez, undoubtedly we have some readers who are 8051 users as well as PIC addicts. And thanks too for your continued interest in EPE!

BASIC STAMP

I have taught myself PICBasic and have a great interest in microcontrollers. What I would like to know is what industries use Basic Controllers and is it hard to start a career using and programming them? Any advice would be greatly appreciated.

Alex, via email

I suspect that in general industry does not use PICBasic types of program, preferring the more universally used assembler codings in various forms. Readers – what are your opinions?

SMOKE DETECTION

Dear EPE,

I am from Les Quennevais school in Jersey. For my business GCSE project I am going to make a photoelectric smoke detector, carbon monoxide detector and heat detector for the deaf. I am wondering if you could send me some circuit diagrams or tell me your suppliers as it would largely help me in my project. Any information that you could give would be very helpful

Alan Morris,
via email

Our Teach In 2002 *series looked at smoke detection in the June '02 issue, back issues can be ordered via our Online site, or according to the information published in each* EPE *issue. We have not done other smoke detectors in recent years.*

STYLOPIC OP.AMP

Dear EPE

I am having problems finding the LM13600 transconductance op.amp for the *StyloPIC* of July 2002, the RS 304-453 is now listed as "no longer stocked". Do you know what other device could be used as an alternative please?

Mike Mackellow,
via email

You can use the LM13700 instead as a direct replacement – no mods needed.

STYLOPIC

Dear EPE,

Following on from your *StyloPIC* in July '02, you might be interested in some info on the original. There were three variations of the pocket model – standard, treble and bass. The treble and bass models being respectively an octave higher or lower (mine is the standard model). Its big brother, the 350S, had many extra features such as short or long envelope, staccato, two speed vibrato, wah-wah, and eight voices.

An innovative feature is a light sensor (l.d.r.) for hand control of vibrato or wah-wah. It also has two styluses (for playing "chopsticks"?). An external amplifier was also available for either instrument, with tone and tremolo controls. On the technical side, the circuit diagram for the pocket version is in the back of the instruction book.

Tone generation is by a programmable unijunction transistor so the waveform would be pulsed, however it is modified by what looks like a diode pump monostable so the mark-space ratio would vary depending on the note frequency (and presumably the harmonics generated). So the output waveform would be something like a square wave with slow rise and fall times. Vibrato is generated by a low frequency phase shift oscillator to vary the programming voltage of the unijunction transistor.

I know John Becker likes to recycle his software so here is something to consider in a future incarnation. It gives greater flexibility of the output waveform. And, of course, you can have multiple waveform tables. This is only an example, other changes may be needed for it to work correctly.

```
OUTIT:   call WAVFORM
         movwf PORTA
         goto MAIN
WAVFORM: andlw $7F   ; Sinewave + 2nd harmonic
         movwf PCL; 128 entries, amplitude
                    0 to 63

DT 00,00,00,00,00,01,02,04,06,08,11,13,16,19,22,26
DT 29,32,35,39,42,44,47,49,52,54,55,57,58,59,59,59
DT 60,60,60,60,60,59,59,59,58,59,59,57,57,57,57,57
DT 58,58,59,59,60,60,61,61,62,62,63,63,63,63,63,63
DT 62,61,60,59,58,56,55,53,51,49,47,45,43,41,39,37
DT 35,33,32,31,30,29,29,28,28,29,29,30,31,32,33,34
DT 35,36,38,39,40,41,42,43,43,43,43,42,42,41,39,38
DT 36,34,32,29,27,24,21,19,16,13,11,08,06,04,03,01
; (DT is "Define Table of retlw's" in MPASM)
```

Peter Hemsley, via email

Thanks Peter. The technical stuff I did not find on the web. The table concept looks interesting. I don't know that I'll ever upgrade StyloPIC *– but who knows?!*

FLOW CHARTS

Dear EPE,

PICs are not my strong point! However, I've started to look at the code for your *PIC Controlled Intruder Alarm* (Apr '02) with a view to modifying it to suit my own purposes. Do you have a flow chart that you could send me?

Trevor Brearley, via email

No, sorry Trevor, I don't do flow charts for my software – I keep concepts in my head and work to those!

Readers who do like to work with flow charts will probably be interested in the Flow Code for PICmicro *CD-ROM that's available via our CD-ROM pages in this issue, and in Terry de Vaux Balbirnie's review of it, also in this issue.*

BIOPIC LEADS

Dear EPE,

I am building the *BioPIC Heartbeat Monitor* (Jun '02) and need to know the order code for Boots' lead pack, together with the information where to order from abroad. The TENS replacement electrode pads you specify are easy to find at almost any Boots shop, but the staff there know nothing about leads, nor how to order. I've tried at several Boots shops on my last trip to London.

Cristian, via email

*Mine came from Boots in Wimborne. I don't know the order code, they were being supplied as normal stock items. If you can't get any, use flexible wire with crocodile clips to clip onto the chest pads. They don't need screening. You could try asking Boots HQ via email (**www.google.com** will provide a web address).*

SERIAL ADC PIC TRICK

Dear EPE,

Readers might be interested in my PIC program for use with the TLC548/9 8-bit serial analogue-to-digital converter. I use file registers COUNT and TEMP as sort of "standard" registers, COUNT for timing etc and TEMP as a sort of second W. It helps me get a mental view of my progs.

In the program this routine comes from, COUNT has previously been reset through DECFSZ, so I can get away with BSF COUNT,3. I have run this at 6MHz without problem, and it should go faster. The A-D value is stored in file UNIT.

```
A2DIN:  BCF PORTB,7       ; clear CS line to
                            hold value to
                            send
        BSF COUNT,3       ; set count to shift
                            8 bits (make
                            sure that
                            COUNT cleared
                            before this sec-
                            tion or use
                            MOVLW etc)
FETCH:  RLF UNIT,F        ; move bits one
                            place left &
                            store new value
                            in UNIT
        BCF UNIT,0        ; set 0 value
                            before Portb,0
                            bit test
        BSF PORTB,6       ; set A2D clock
                            pin high, release
                            bit for transfer
        BTFSS PORTB,5     ; is bit 0 (DOUT)
                            set ?
        GOTO NEXT1        ; no, then leave
                            UNIT bit 0 value
                            as is
        BSF UNIT,0        ; yes, set bit 0 of
                            UNIT
NEXT1:  BCF PORTB,6       ; clear clock pin
        DECFSZ COUNT,F; is COUNT zero?
        GOTO FETCH        ; no, get another
                            bit!
        BSF PORTB,7       ; yes, 8 bits
                            clocked out &
                            held in UNIT,
                            set CS line to
                            get new value
        RETURN
```

Graham Card, via email

Useful, Graham, thank you – I've put it in the PIC Tricks folder on our ftp site.

FREEZER ALARM

Dear EPE,

I've been reading Humphrey Berridge's *Freezer Alarm* in the May '02 issue, and I'm extremely impressed with the low component count for the functionality achieved, but I'd like to make a suggestion:

The piezo sounder needs to be as loud as possible, but it's only being fed with 5V pk-pk from pin GP4 to ground. If you connect the sounder between GP4 and GP5, and feed GP5 with an inverted signal, you will get 10V p-p drive in a bridge configuration – twice the voltage, at no extra cost!

The only changes required are to the sweep2 and sweep3 routines:

```
sweep2  bsf output      ; output high
        bcf output2     ; output2 low – added
        decfsz freq,f
        goto sweep2
        movfw nfreq
        movwf freq
sweep3  bcf output      ; output low
        bsf output2     ; output2 high – added
        decfsz freq,f
        goto sweep3
```

Plus an extra define line:

#define output2 gpio,5 ; inverted o/p to piezo sounder

Nigel Goodwin, via email

Thanks Nigel!

LOTTERY PREDICTOR

Dear EPE,

I am studying GCSE Electronics. My father has been purchasing *EPE* since 1994 and is still enjoying each new edition. In the April '95 issue I came across the *National Lottery Predictor* project and am wondering if you could please send me as much information on that topic as possible to further my knowledge and passion.

Gopyr, via email

So sorry, but we cannot provide additional material for any published design. Regarding building a circuit from 1995, we normally advise against attempting to build a design that is over five years old since parts could well have become obsolete during that time.

In this particular case, the p.c.b. is no longer available, nor will you be able to obtain the programmed PIC as we are no longer in touch with the authors, and they did not sell us the copyright to their software (that was before we began to insist that all project software must be made freely available to readers).

EARTH RESISTIVITY LOGGER

I am designing an "Earth Resistivity Logger" for archeological use, inspired by Robert Beck's Earth Resistivity Meter *of Jan/Feb '97. Mine is PIC controlled and will have its own non-volatile memory (data stays held even after switch off); possibly a graphics l.c.d. may show rough details of reading values as grey scale; serial interface for connection to PC for deeper analysis.*

I am not an archeologist and am approaching the design purely as an electronic problem to be solved – send an output signal, retrieve it from a distance and store the value. I am in communication with a local archeological society, but I would be pleased to hear from any EPE *readers involved in this field, with special regard to the following:*

- How many reading samples do you normally take on a site in one main session?
- How many samples would you like the logger to store before download to PC?
- Is powering it from a 12V car battery adequate, or do I need ±18V as Robert had?
- What probing techniques do you use? I'm assuming the twin-probe technique is best, as described by Robert.
- What maximum probe separation distance do you use?
- How deep do you insert the probes?
- Is a signal frequency of 137Hz as used by Robert the best to use?
- In your experience, how likely is it that 50Hz mains frequency is likely to occur on a site being surveyed, and would thus need to be filtered out in some way?
- Do you always plot the site squares in the same regular order, or would you prefer to sample in random order, telling the logger the square number being sampled?

*Any answers would be appreciated, my email is **john.becker@wimborne.co.uk**.*

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

CONCERNS about finished projects failing to work are probably the main reason for would-be constructors failing to "take the plunge". It is not a major concern for those with years of project building experience because they have the technical knowledge, equipment, and know-how to deal with practically any problem. The opposite is true for beginners who, on the face of it, have little chance of dealing with projects that refuse to work.

Keep it Simple

In reality the situation for beginners is better than it might seem. Provided you start with something reasonably simple and follow the instructions carefully there is a good chance of success. Pre-publication checking for both books and articles containing electronic projects has increased over the years, and this has greatly reduced the chances of being led astray by printing errors. On the rare occasions that an error does creep in to an *EPE* article it is usually spotted quite early and corrected one or two issues later.

In general, the complexity of modern projects is greater, but your chances of failure if the instructions are followed "to the letter" are much less than they were. Like any creative skill, electronic project construction would not be a worthwhile hobby if perfect results were guaranteed every time with no skills required. You have to be prepared to put in some effort and try to go about things the right way.

It is worth repeating the importance of choosing a project that is within your capabilities. It is tempting to dive straight in with a project that will impress your friends, but the more complex the project the greater the risk that you will make a mistake. In the past it was not unusual to receive letters from readers having problems with projects that they clearly did not understand at all.

You do not need to know how a project works in order to build it successfully, but you do need to have a proper understanding of what it is supposed to do and how it is used. Something like a household gadget is a more appropriate starting point than an advanced piece of test equipment where you need a degree in physics in order to switch it on!

Fortunately, letters from readers who have "bitten off more than they can chew" are relatively rare these days, but it is still a problem to take seriously.

Mains Point

The mains supply is ***potentially lethal***, as are projects that connect to it. Mains power projects are only suitable for those with a reasonable amount of experience at project construction. Even if a project is very simple, if it connects to the mains supply it is certainly not suitable for a beginner.

Start with projects that are battery powered. If you should make a serious blunder it is possible that one or two of the components will be damaged, but *you* should be perfectly safe. In most cases all the components will survive the experience as well.

The two main construction methods used in modern projects are stripboard and custom printed circuit boards (p.c.b.s). While both types of board are pretty straightforward to use, custom printed circuit boards represent the more foolproof option. Stripboard is a multi-purpose circuit board that has a regular matrix of holes, and in most projects only a few percent of these are actually used.

As its name suggests, a custom printed circuit board is specifically designed for a particular circuit and normally has just one hole per leadout wire or pin. With a custom board there is relatively little risk of making a mistake in the first place, and any errors that should creep in are likely to be spotted almost immediately. With stripboard there are hundreds of unused holes that are good at disguising mistakes, and some very careful checking is needed to detect them.

Bridging the Gap

Having chosen a suitable project and put it together with due diligence, what do you do if the finished unit fails to work? When a newly constructed project is clearly failing to work properly it is not a good idea to leave it switched on.

Leaving a faulty project switched on could result in damage to some of the components, and the semiconductors are particularly vulnerable. Always switch off faulty projects immediately and then recheck the component layout, wiring, etc.

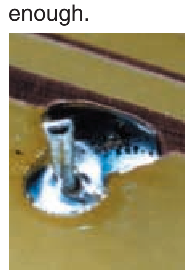
The prudent project builder checks all this sort of thing very carefully during construction, and spotting errors early can save a lot of hassle latter. In order to properly check the unit you may have to partially dismantle it in order to get proper access to the circuit board.

Years of practical experience suggest that the vast majority of problems are due to "short-circuits" between copper tracks on the underside of the circuit board. This is not exactly a new problem, but the intricacies of modern boards make it even more problematic than in the past.

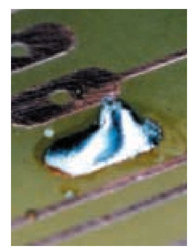
Unless the board is coated with a solder resist that is designed to discourage solder bridges, it is likely that several will be produced per circuit board. Most of these bridges will be spotted while you are constructing the board, and in most cases they are easily removed using the bit of the soldering iron. If there is a lot of excess solder it is better to use a desoldering tool, and an inexpensive desoldering pump is ideal for this application. It is advisable to remove as much solder as possible and then redo any joints that have been desoldered.

Hidden from View

The more difficult problem is minute trails of solder that are often difficult or impossible to see with the naked eye. The situation can be made more difficult by the trails being hidden under excess flux from the solder. This tends to get liberally splattered across the underside of circuit boards during construction. There are various products that can be used to thoroughly clean the flux from boards, but vigorous brushing with a small brush such as an old toothbrush seems to do the job well enough.



A "dry" joint. Solder failed to flow.



A good joint, nice and shiny.

Photos courtesy Alan Winstanley's *Basic Soldering Guide*

Good eyesight is not sufficient to guarantee that any solder bridges will be spotted. Some form of magnifier now has to be considered part of the standard toolkit for electronic project construction, and even a small magnifying glass will greatly increase the chances of detection.

An 8x or 10x loupe (also sold as lupes) is better though. The inexpensive types sold as photographic accessories for viewing slides and negatives are perfectly adequate for the present application.

Provided the board is thoroughly cleaned first, a careful visual check using a magnifier should reveal any solder bridges. As solder bridges occur so often it is a good idea to clean and visually inspect all completed circuit boards prior to installing them in the case.

Hot Spots

Dubious soldering is a common cause of problems, particularly amongst beginners. Soldering is like any skill, and it is a case of "practice makes perfect". The more projects you build the more proficient you will become at completing soldered connections. There is insufficient space here for a "soldering tutorial", but a

good one is available at the *EPE* web site. Some soldering irons and soldering kits are supplied with detailed instructions, and it is well worthwhile studying these.

Probably the most common cause of so-called "dry" joints is the soldering iron being left unused for a few minutes before starting a new batch of connections. If there is a substantial amount of solder left on the bit, any flux in it will burn away and it will probably start to oxidise. If you produce the next joint without cleaning the end of the bit first, the joint will contain a significant proportion of old solder, which may not flow over the joint properly.

The resultant joint might look plausible and could seem to have good mechanical strength as well. However, joints of this type usually provide only intermittent electrical contact or no contact at all, and are relatively weak mechanically.

Shining Example

Always make sure that the bit is tinned with fresh solder prior to making joints. Practice soldering with some bits of wire, a few resistors, and a scrap of stripboard before you start building projects. This will cost very little and will greatly enhance your chances of success.

Checks with a continuity tester or the continuity function of a multimeter should locate dry joints, but thoroughly checking even a small circuit board can be quite time consuming. Large amounts of excess flux are sometimes indicative of a bad joint, but this is of no help once the board has been cleaned.

Good joints normally have a characteristic mountain shape and the surface of the solder is very shiny. "Dry" joints are often more spherical in shape and the solder tends to have a relatively dull surface, possibly with some crazing.

Clean Break

If any joints look suspicious it is probably worthwhile desoldering them and then re-soldering them. Before trying again it is a good idea to have a close look at the two surfaces. These days it is unusual for dirt or corrosion on one of the surfaces to cause problems. Modern components are less vulnerable to corrosion on the leadout wires and tags, and the flux in electrical solders is very efficient at dealing with contaminants.

However, there can still be occasional problems though, and if there is any sign of contamination it is a good idea to clean both surfaces before redoing the joint. The best way to clean the surfaces is to gently scrape them with the small blade or a penknife, a miniature file, or something of this type.

The driest joint of all is the one you forget to do! Missing joints are usually fairly obvious with custom printed circuit boards, but can be difficult to see with stripboard where there are numerous unused holes and no pads as such. Firmly pulling on resistors, capacitors, diodes, etc., will reveal any missing joints, or ineffective joints that look plausible.

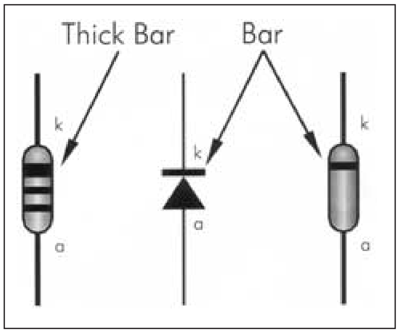


Fig.1. The wide band indicates the cathode (k) leadout of multi-band diodes.

Heat of the Moment

Apart from semiconductors, modern components are reasonably tolerant of heat. However, it is still possible that damage will occur if you take too long to complete joints. Heat damaged components usually show some obvious signs of damage, such as a darkening in colour or being slightly misshapen. Always replace any "off colour" or deformed components, or any components that show significant signs of physical damage.

Integrated circuits (i.c.s) are mostly fitted in holders, but transistors and diodes are often connected directly to the circuit board. Always take extra care when fitting these in place. As pointed out previously, it is a matter of "practice makes perfect", and you can avoid a lot of problems by learning to solder quickly and neatly before dealing with transistors and diodes.

Try and Try Again

Having thoroughly checked both sides of the board and made any necessary repairs it is time to reassemble the project and test it again. Thoroughly check the hard wiring against the wiring diagram, as it is relatively easy to make mistakes here. If the project still does not work, the most likely explanation is that you have missed an error in the wiring or on the circuit board.

With this type of thing there is a tendency to blame others and not accept that you could have made a mistake. In reality it is easy to make the odd mistake here and there, and even "old hands" make the occasional error.

Start by checking that every component on the circuit board is in the right place and has the correct value. Work through the components methodically making sure that none of them are overlooked. If you have managed to miss out a component, this error should then come to light. With stripboard construction make sure that any link wires are present and correct.

Ideally you should get someone else to check the unit against the construction diagrams. A fresh pair of eyes might spot something that you have consistently overlooked.

Wrong Connection

The components that must be fitted the right way round are the most likely to give problems. Layout diagrams and the markings on components such as diodes and electrolytic capacitors are usually quite explicit, so any errors should be easily spotted.

One exception is the type of diode that has several bands rather than one at the cathode ("k" or "+") end of the component. These have had something of a renaissance in recent times, so you may well encounter them. The bands indicate the type number using a variation on the resistor colour code. A wider band at that end of the body (Fig.1) indicates the cathode (k) lead.

Light emitting diodes (l.e.d.s) can also be problematic. If a project works apart from a l.e.d. indicator, it is odds-on that the l.e.d. is simply connected the wrong way round.

A Pressing Connection

Before too long practically everyone makes the classic mistake of forgetting to switch on the project or omitting that all-important component – the battery. Battery connectors have always been notoriously unreliable. Try pressing the connector firmly onto the battery to see if it makes the project burst into action. Slightly compressing the female connectors with pliers usually gets a loose clip to work reliably.

Battery holders for 1·5V cells are also something less than totally reliable. Ensure that the terminals of the batteries and the holder are clean by gently removing any contamination with fine sandpaper.

Multi-checks

A cheap multimeter is useful for checking that the battery voltage is actually getting through to the circuit board. It can also be used to check that the battery is in a usable state.

Even if you do not have much technical knowledge, a multimeter can still be useful for numerous basic checks. For example, it can be used for making continuity checks on switches, which may not operate in quite the way you think they do?

Have you confused the "on" and "off" settings? Often when a project seems to be working irrationally it is just that one of the switches does not function as expected. The high and low ranges are transposed, or something of this type.

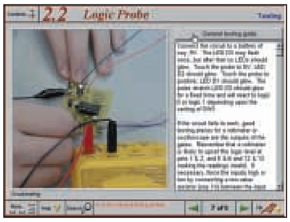
A multimeter is also useful for checking cables for short-circuits or broken leads, checking that that plugs and sockets connect together properly, etc. Even some of the cheaper digital types now have the ability to check resistors, transistors, diodes, and capacitors, which is clearly more than a little useful. *A multimeter is a piece of equipment that no project builder should be without.*

Because modern components are very reliable you are unlikely to have a failure caused by a dud component. If you get everything connected together properly your projects will work, and it helps to keep this in mind. Of course, the projects will never work if you do not pluck up the courage to "take the plunge" and actually build them.

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

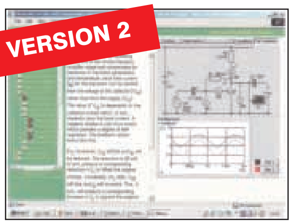


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

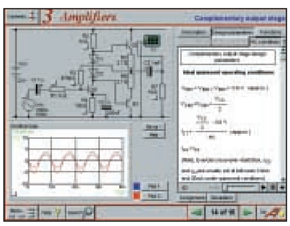
VERSION 2



Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

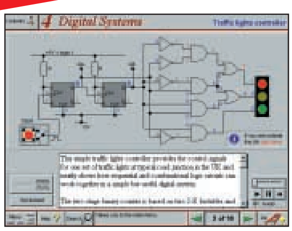


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

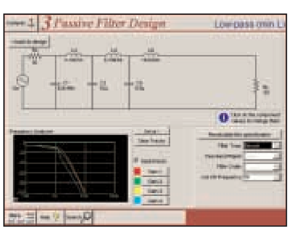
VERSION 2



Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

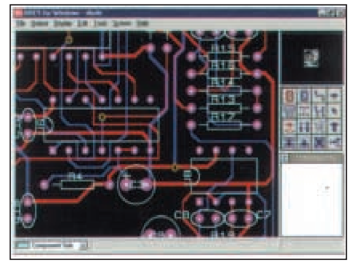
FILTERS



Filter synthesis

Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

ELECTRONICS CAD PACK

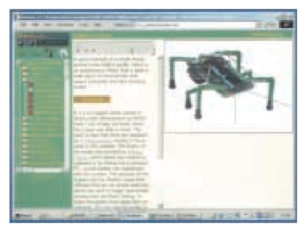


PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

NEW

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Full case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student ....£45 inc VAT
Institutional (Schools/HE/FE/Industry)..............£99 *plus* VAT
Institutional 10 user (Network Licence) ....£199 *plus* VAT
Site Licence...£499 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

PICmicro TUTORIALS AND PROGRAMMING

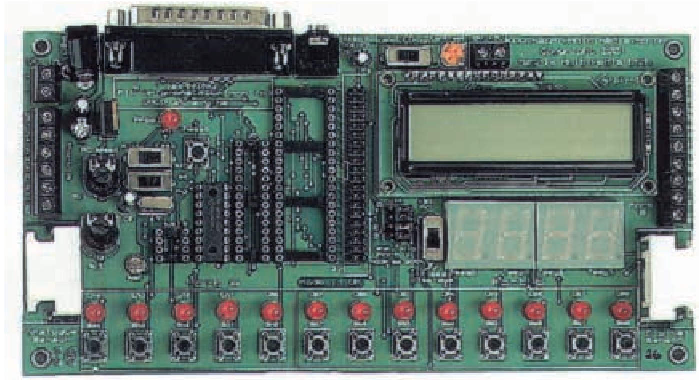
HARDWARE

VERSION 2 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 13 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- All inputs and outputs available on screw terminal connectors for easy connection



£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

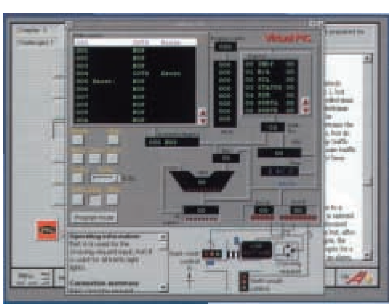
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V2.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro micro-controller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 39 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.



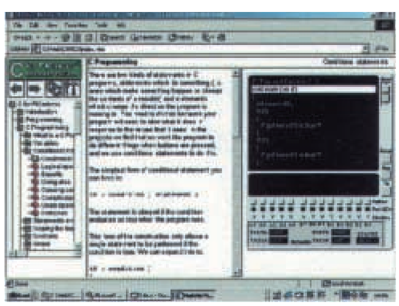
Virtual PICmicro

'C' FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

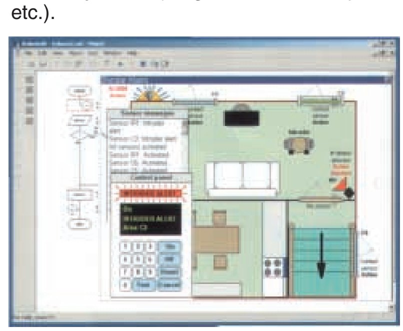
FLOWCODE FOR PICmicro

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 8, 18, 28 and 40-pin devices ● Institutional versions include virtual systems (burglar alarms, car parks etc.).



Burglar Alarm Simulation

PRICES

Prices for each of the CD-ROMs above are:

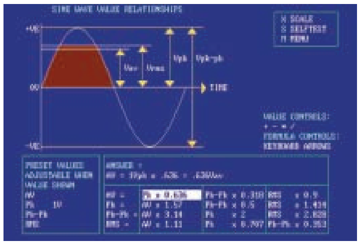
(Order form on next page)

Hobbyist/Student	**£45 inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99 *plus* VAT**
Flowcode Institutional	**£70 *plus* VAT**
Institutional 10 user (Network Licence)	**£249 *plus* VAT**
Site Licence	**£599 *plus* VAT**

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

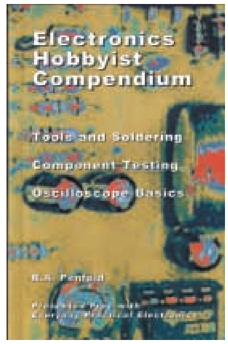
TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE

EPE's own *Teach-In* CD-ROM, contains the full 12-part *Teach-In* series by John Becker in PDF form plus the *Teach-In* interactive software covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed *Basic Soldering Guide* which is fully illustrated and which also includes *Desoldering*. The *Teach-In* series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers, Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue.



Sine wave relationship values

FREE BOOK WITH TEACH-IN 2000 CD-ROM



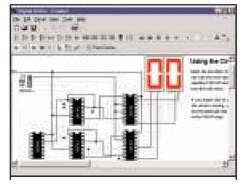
Each part has an associated practical section and the series includes a simple PC interface so you can use your PC as a basic oscilloscope with the various circuits.

A hands-on approach to electronics with numerous breadboard circuits to try out.

£12.45 including VAT and postage. Requires Adobe Acrobat (available free from the Internet – **www.adobe.com/acrobat**).

FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.

DIGITAL WORKS 3.0


Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

Hobbyist/Student £45 inc. VAT.
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Institutional 10 user £199 *plus* VAT.
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ELECTRONICS IN CONTROL

Two colourful animated courses for students on one CD-ROM. These cover Key Stage 3 and GCSE syllabuses. **Key Stage 3:** A pictorial look at the Electronics section featuring animations and video clips. Provides an ideal introduction or revision guide, including multi-choice questions with feedback. **GCSE:** Aimed at the Electronics in many Design & Technology courses, it covers many sections of GCSE Electronics. Provides an ideal revision guide with Homework Questions on each chapter. Worked answers with an access code are provided on a special website.

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Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

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A high quality selection of over 200 JPG images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).

Also contains a **FREE** 30-day evaluation of Paint Shop Pro 6 – Paint Shop Pro image editing tips and on-line help included!

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Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

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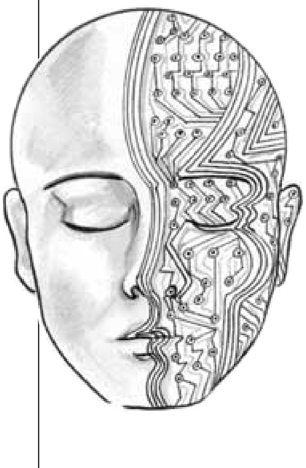

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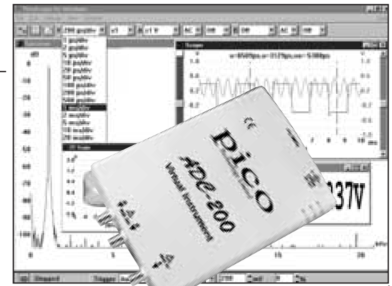

Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas *must be the reader's own work* and **must not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.** Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited,* Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown Dorset BH22 9ND. (We **do not** accept submissions for *IU* via E-mail.)
Your ideas could earn you some cash **and a prize!**

WIN A PICO PC BASED OSCILLOSCOPE WORTH £586

- 100MS/s Dual Channel Storage Oscilloscope
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- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.
Every 12 months, Pico Technology will be awarding an ADC200-100 digital storage oscilloscope for the best IU submission. In addition, a DrDAQ Data Logger/Scope worth £69 will be presented to the runner up.

Switched Mode Fan Regulator – A Cool Turn

THE circuit diagram shown in Fig.1 was developed as a controller for a 12V 1A d.c. fan. It is a switched-type regulator which is more efficient than a linear type. A sawtooth generator is derived from IC1, via the timing components resistor R1, capacitor C4 and diodes D1 and D2.

The waveform is fed to non-inverting input (pin 3) of IC2. This compares the difference between the sawtooth and a reference voltage produced by potentiometer VR1, and creates an output pulse that drives a MOSFET power transistor TR1.

The remaining components including inductor L1 and diode D3 are used to create a smoothed d.c. voltage which powers the d.c. fan. Resistor R4 is a dummy load and by adjusting VR1, the duty cycle can be adjusted.

Capacitors C1 to C3 decouple the supply, and note that electrolytic capacitors C6 to C8 were placed in parallel to reduce their overall effective series resistance (ESR) together with any associated heating effects.

Myo Min,
Yangon, Myanmar.

555 Astable – Simpler Solution

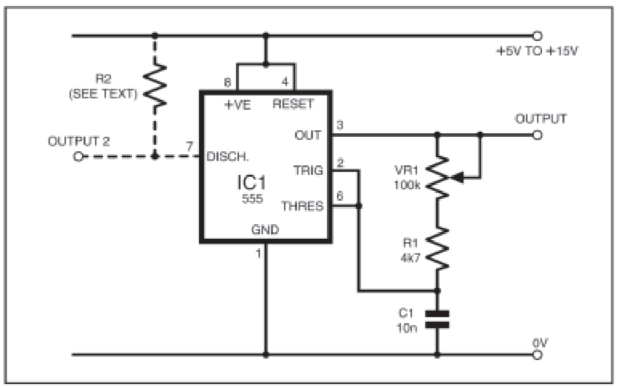


Fig.2. Circuit diagram for an alternative 555 Astable.

INSTEAD of using the usual circuit set-up, if the charge/discharge current for the timing capacitor is taken from the output (pin 3) of the 555 timer i.c. then an astable multivibrator can be made using just three external components as shown in Fig.2. An alternative output can be taken from pin 7, the "discharge" pin, using it as an open collector output port, thus isolating the load from the *RC* timing network. Select the load R2 to suit.

The mark: space ratio appears to be around 3:2 but gets worse below 5V or so. With the values shown, the frequency range is around 500Hz to 8kHz.

P. Tomlinson,
Hull, East Yorkshire.

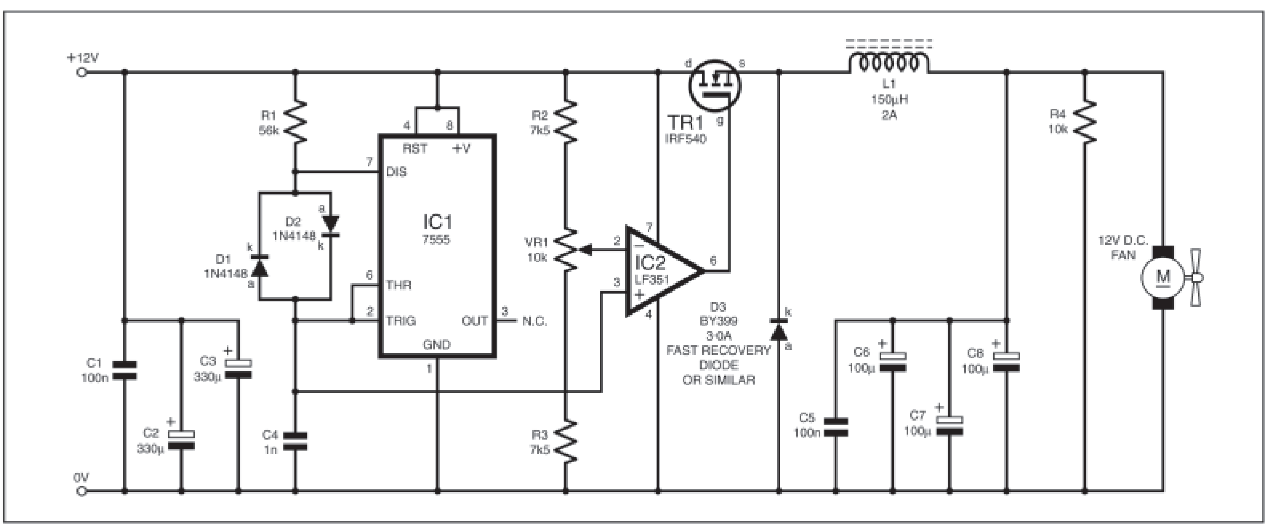
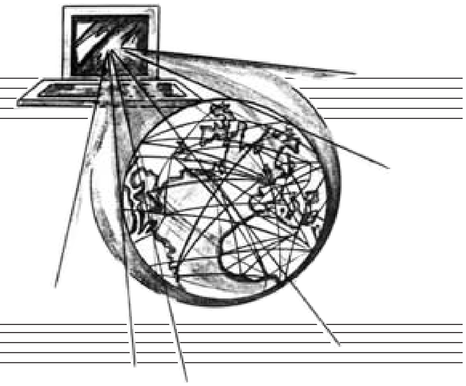


Fig.1. Circuit diagram for the Switched Mode Fan Regulator.

SURFING THE INTERNET

NET WORK



ALAN WINSTANLEY

WELCOME to *Net Work*, our column written for Internet users. Regular users of our Internet site **www.epemag.wimborne.co.uk** can view the outline contents of each issue by visiting the Recent Issues page (**/issues.htm**) which features a photo or two of all our latest projects, with hyperlinks to pages describing the last four years or more of *EPE* projects as well.

You can view or download indexes of previous volumes of EPE by visiting /idxpage.htm – the latest indexes are in PDF format. On the same index pages, any "Please Take Note" updates are also available on line.

Frantic about FTP?

It is worth reminding readers and newcomers that our FTP site **ftp://ftp.epemag.wimborne.co.uk/pub** hosts our free source codes for almost all our PICmicro projects and more besides. You can download source code using FTP software such as the freeware version of WS_FTP from **www.ipswitch.com**, and all popular web browsers recognise FTP files as well. You may need a Zip utility such as WinZip (from **www.winzip.com**) to unzip some files; check **download.com** for a huge range of programs, freeware and shareware.

Some readers do seem to struggle when trying to access the FTP site, resulting in a (sometimes hostile) email being delivered to the writer. There is more to the Internet than web pages! File Transfer Protocol is a universal way of managing the transfer of an array of files. The best online resource for help with FTP is **www.ftpplanet.com**, which you should bookmark.

From experience, the main reasons why problems arise are because:

1. A commercial firewall is preventing FTP access. This often happens when trying to access the FTP site from a workplace. Readers report success when they try to access the site from home instead.

2. Folder View has been disabled in your web browser. In Microsoft Internet Explorer, go Tools/Internet Options/Advanced/Browsing/Enable Folder view for FTP sites (tick yes).

As a service for those with an aversion to FTP, Thomas Stratford maintains a web-style mirror site for our PICmicro source code at **http://homepages.nildram.co.uk/~starbug/epepic.htm**.

Broadband Thermometer

The haphazardous rollout of broadband services across the UK continues in its usual lottery-like manner. British Telecom is focussing on ADSL (Asymmetric Digital Subscriber Line) for the masses, which provides a download speed over a phone line of up to ten times the speed of an ordinary 56kbps modem, with the added advantage that it can be "always on".

British Telecom states that ADSL now covers 66% of all households. Cable or costly satellite or wireless access could be the only options for the remaining 34%. To help BT gauge the demand they have recently introduced a "pre-registration" facility on their web site (**http://www.bt.com/broadband/**). I decided to head over there to take a look.

I found a broadband availability checker, a pre-registration check, and a list of participating ISPs. The availability checker is a thermometer display indicating the level of interest in ADSL in your area. Unfortunately, for my own telephone exchange the thermometer is a worrying shade of ice blue.

A number of BT exchanges have been assigned a "trigger level" and in theory you can "pre-register" your interest in ADSL for that exchange. Then over time you can sit back and watch the virtual thermometer warm up and hit the roof, signifying that the exchange will finally be upgraded because the trigger level has been achieved (or not).

"The size of your exchange indicates that ADSL may not be viable," said the online form in my case. Unfortunately my exchange does not even have a trigger level allocated to it. Anyway, choosing a compatible ISP (let's try BT Openworld for starters, I thought) to handle my registration had no effect on the "temperature"; two weeks later there has been no contact from BT Openworld and the thermometer is still stuck firmly in the deep freezer department showing zero.

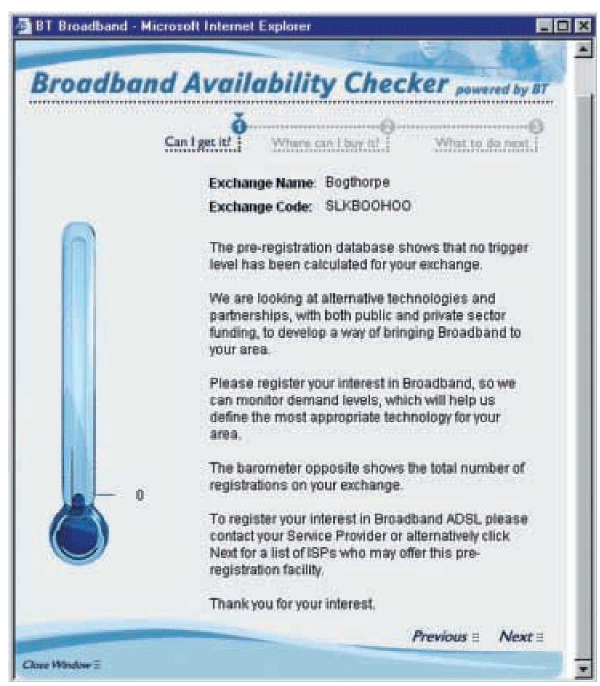
The problem with the pre-registration scheme is that you can only register your interest through a participating ISP, who then passes it on to BT Wholesale. Evidently some ISP's are not forwarding pre-registration enquiries, which means that the registration figures and therefore the levels of interest are going to be understated.

LeechGet Your Files

Seasoned web surfers know that right-clicking an image or filename opens a pop-up menu allowing you to Save Target As... Internet Explorer 6 offers provides icons for saving, when your mouse pointer hovers over an image. Recently I came across a free utility program for Windows that enhances the file download process. LeechGet (fetch the English version from **www.leechget.de**) offers further right-click options in the pop-up menu, and the program allows you to split the download in any number of sections and download them in parallel.

The main attraction is that by using the wizard you can see whether the server allows you to resume downloads following an interruption (e.g. your connection times out). There is no need to re-fetch the portions already downloaded. The download progress is also shown in the task bar area. This is an attractive and worthwhile program that has quickly become my standard means of fetching any files over a hundred kilobytes or so – download it now and see.

Next month I'll take a look at ways you can grab entire web sites to save onto your hard disk. You can email me at **alan@epemag.demon.co.uk**.



BT's online Broadband Availability Checker is decidedly lukewarm at times. Stone cold in fact.

Special Review

FLOWCODE FOR PICmicro

plus PIC DEVELOPMENT BOARD

TERRY de VAUX-BALBIRNIE

Terry casts an appraising eye over two new products

DOWN TO BASICS

FOR READERS who are not yet familiar with PIC devices, these are programmable integrated circuits and comprise a family of microcontrollers from Arizona Microchip.

A PIC is manufactured in an "empty" condition. Unlike conventional i.c.s which have some dedicated purpose, a PIC will only perform the task you have in mind if you program it within the limits set by the manufacturer's parameters. It can then perform a wide variety of jobs, replacing all manner of conventional i.c.s, and may be cost effective even when the circuit is fairly simple. In more complex applications, a single PIC may replace a number of "ordinary" i.c.s.

Many projects published in *EPE* are PIC-based. To construct these, readers may wish to program their own PIC or buy the ready-programmed device. However, for those wishing to develop their own PIC circuits, some means of programming them is clearly necessary. This work is done in two stages. First, the program is worked out ("written") and any faults ("bugs") removed from it. Second, it is "assembled" and transferred to the PIC.

WORKING FOR YOU

If you are itching to see what a PIC can do for you, and have possibly been put off by reading textbooks, then *Flowcode* could be a very good choice. This is a piece of computer software that teaches you about PIC microcontrollers and shows how to program a "virtual" (make believe) device. Its great strength is that *you need to know nothing about PIC programming theory!*

When you are ready to write your own programs, all you need is a clear idea of what you want the PIC to do. This is then entered on the screen in the form of a flow chart using standard flow chart symbols. It will then simulate the action of the PIC. You may play around to your heart's content without touching a real PIC! This is as good as hand-on experience, but is faster and costs nothing (apart from the initial outlay).

REQUIREMENTS

To use Flowcode, you will need (as a minimum requirement) a PC with a Pentium processor and having a CD-ROM drive, 32MB of RAM and 20MB of hard disk space. It is designed to be run under Windows 98/ME/XP/NT/2000. It *cannot* be guaranteed to run using Windows 95.

The software serves the purpose of developing the program while the associated *PIC Development Board* hardware may be used to transfer the program to a real PIC. Note that the Development Board may be used to program PICs from files not necessarily derived from Flowcode.

For those who simply wish to learn about PICs and work on their own programs, the software may be used on its own. Users who would like to get their hands on a real PIC and make it work in a circuit will need both the hardware and software products.

ASSUMED KNOWLEDGE

Users of these products will range from those having a fairly limited knowledge to experts in conventional (pre-PIC) electronics. Some will only wish to gain an idea of what a PIC can do while others will want to write complex programs. Flowcode assumes that the user has sufficient existing electronics knowledge to use it effectively.

Although not meant for the complete beginner, the necessary knowledge is easily gained from other sources. There are some inexpensive textbooks and useful pieces of software available.

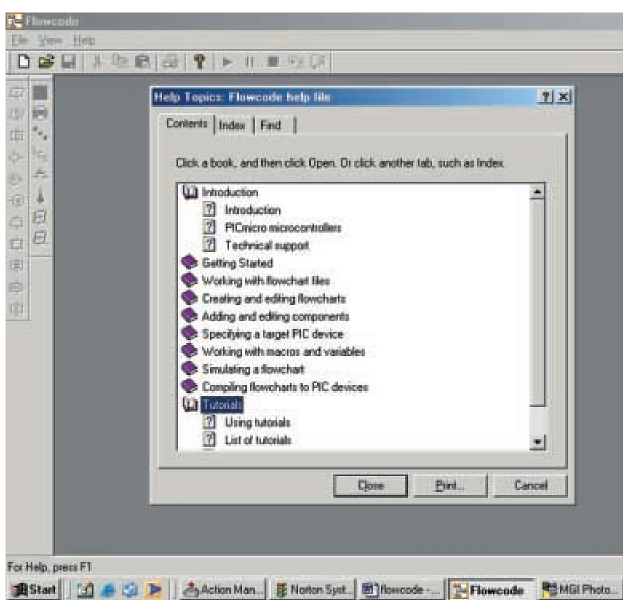
You will also need some background knowledge regarding what PICs are and what they can do. You need to be reasonably computer-literate (if you can use the usual Windows operations such as *cut, paste, print, save,* etc. that will probably be sufficient).

You should know the difference between analogue and digital signals, be familiar with logic states and have some understanding of simple electronic components such as l.e.d.s, switches, seven-segment displays, etc.

It will probably be found easier working in a school or college environment where there is access to a teacher or lecturer. It may be harder for those working on their own. Even so, Flowcode's interactive nature makes it ideal for home study and, after all, such users can work as slowly or as quickly as they need to.

TWO PART SERIES

There are two elements to Flowcode – the program itself and the *help topics*. The latter may be opened separately or from within Flowcode. Here, there is an explanation of the subject matter (the "contents"),



The Help Topics in Flowcode.

also an alphabetical index and search facilities. These will be found useful at a later stage to locate a particular section.

The subject matter begins with an introduction and "getting started" and ends with a list of some 28 practical tutorials. These are worked examples of flow charts that may be run on a "virtual" PIC to see how they behave.

For someone having only a minimum amount of knowledge, it seems best to read through the first few topics briefly before doing anything else. This will check whether anything needs to be brushed up on before proceeding.

The foundation work might seem daunting and it must be read slowly or the user might become discouraged. It would be best not to take too much notice of special terms initially because they might not be necessary to follow the first few tutorials. They may be looked at in more detail as they are needed.

When the first few topics have been read, it would then be a good idea to look at the first tutorial or two and see how things work from a practical perspective. Back and forth reading from the help topics and from elsewhere goes in parallel with the tutorials.

There are icons for the various flow chart boxes and for input and output devices (such as switches and l.e.d.s). By dragging a box on to the flow chart, an arrow appears at the insertion point and the flow chart expands to include the new elements.

A very powerful technique is to call *macros* into a flow chart. These are blocks of flow chart programming obtained from another flow chart and saved as a single icon.

Flowcode operates by first translating the information from the flow chart into C language. It is then compiled and assembled using Arizona Microchip's MPASM assembler (which is supplied on the CD-ROM) into an ASM file. However, all this goes on in the background without the user being aware of it.

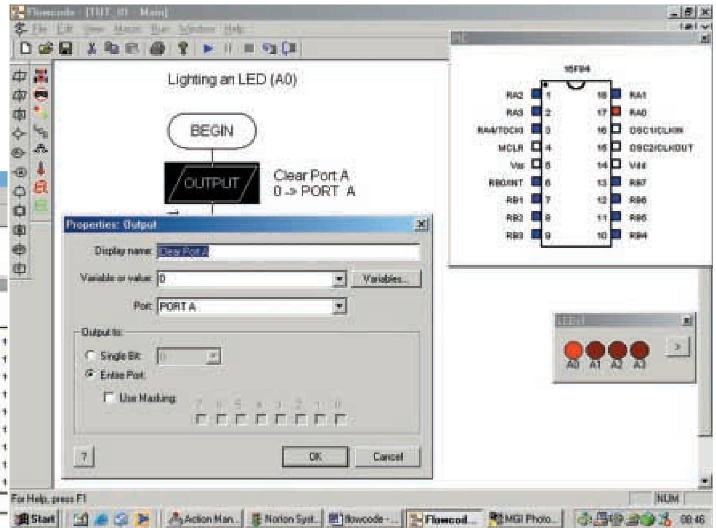


Fig.2. The editing properties.

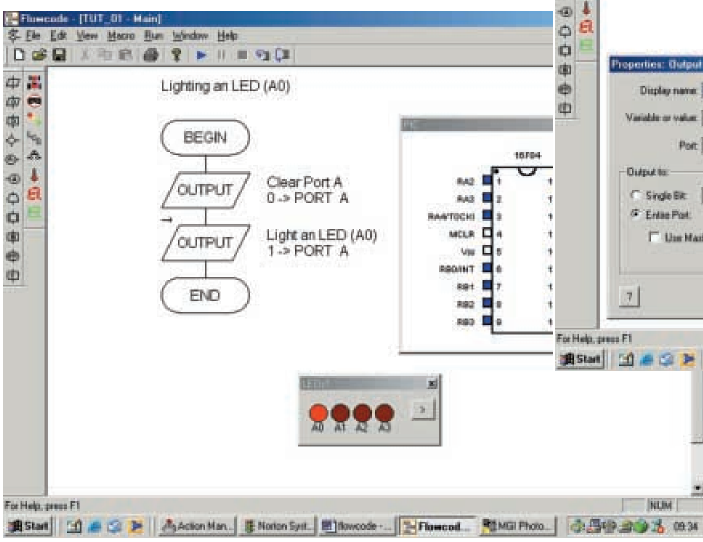


Fig.1 (left). The first Flowcode Tutorial, "Lighting an L.E.D."

TUTORIALS

To use the tutorials from within the program you need to "open an existing Flowcode flowchart" whereupon a list of tutorials appears. Double-clicking on the first one (TUT_01) brings up the working screen with the first example on it (see Fig.1). At the top, there is a statement about what the PIC is going to do (in this case, Lighting an L.E.D.) and a flow chart complete with Begin, End and Output boxes appears.

The output boxes are defined in terms of what they do. There is (optionally) a pin diagram of the PIC (labelled with its type) and a row of four light-emitting diodes (l.e.d.s).

MAKING IT WORK

Nothing happens until you click *Run* then *Go/Continue* (or press the ">" arrow on the toolbar). The program then runs and the appropriate l.e.d. "lights up" (goes red). The PIC diagram (if displayed) also shows the pins that go high and low by turning from blank to red and blue respectively.

By pressing ">" in the LED box, the connections between the l.e.d.s and the PIC may be displayed and edited and in *properties*, the l.e.d. colour may be changed to green, yellow or blue and the number of l.e.d.s in the group altered from one to eight. A complex program may be run step-by-step. The clock speed may also be varied and can be made as low as 1Hz to watch the effect at each stage.

It is very rewarding to modify a tutorial by editing it, perhaps very gently to begin with and note the effect when the program is run. Double-clicking a flow chart box will bring up the properties which may then be changed (see Fig.2). Sorting out the reason if it fails to work as expected is highly instructive.

GAINING CONFIDENCE

When you feel confident, you will be able to create your own flow charts. When opening up a new window to do this, Begin and End boxes appear automatically because these are always needed. The flowchart is then built up by dragging icons from toolbars on to the diagram.

DEVELOPMENT BOARD

The PIC Development Board is a piece of hardware that plugs into your computer parallel port (see photograph). To use it, you will need (as a minimum requirement) a PC having a 100MHz Pentium processor running Windows 98/ME/NT/2000/XP (again, it cannot be guaranteed to run in Windows 95). It should have a parallel printer port, 1MB of hard drive space and 16MB of RAM.

The board is supplied in a case identical to a VHS cassette box together with software and documentation on a 3·5 in. floppy disk. The documentation is comprehensive and it might be best to print this out so that it is available for quick reference.

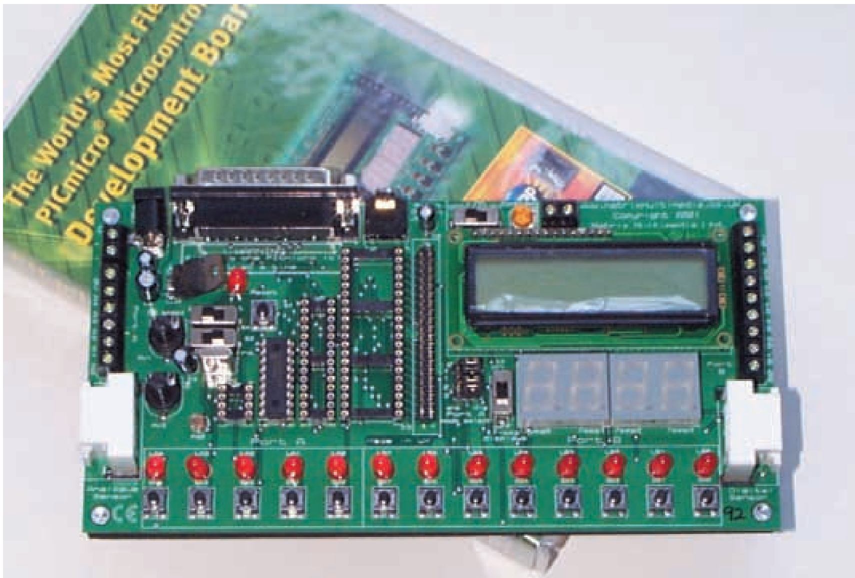
The board receives the assembled file from the computer and programs the PIC which is plugged into it. This may be done simply by clicking "compile to PIC" from the RUN menu in Flowcode. After that, the PIC may be run on the board. It may then be removed if need be and transferred to a custom-made p.c.b.

Having designed electronic circuits for many years, the PIC Development Board certainly seems very nicely made and sufficiently robust for all normal purposes. The underside has a foam backing lightly stuck in place. This will protect the work surface from scratching, insulate it from any conducting objects and prevent fine copper tracks from becoming broken if it is placed on something sharp.

This board is also compatible with the associated CD-ROMs *Assembly for PICmicro V2* (formerly *PICtutor*), and *"C" for PICmicro V2.*

PLUGS AND SOCKETS

Fitted with a 25-way D-type plug, the board connects via a standard parallel lead to the computer parallel port. On top of the board, there are turned pin sockets for 8, 18, 28 and 40-pin PICs (most types are supported). A PIC16F84 is already fitted when supplied. This is electrically re-programmable and should provide up to 1,000 programming cycles. Replacements are widely available if required.



The PIC Development Board and "VHS type" storage box.

The board is said to be short-circuit proof on all inputs and outputs although this was not tested. A plug-in power supply unit is available although a suitable 12V d.c. 500mA (minimum) unregulated unit may already be to hand. This is connected via a standard "power-in" type socket.

MAKING SENSE

Although the supplied PIC16F84 has no analogue-to-digital converter, such devices are fully supported and there is an on-board l.d.r. type light sensor and an "analogue sensor simulator" (potentiometer). Various external sensors such as for light, sound (microphone), temperature, pH, dissolved oxygen, gas pressure and heart rate are available as optional extras. These enable the programmed PIC to be used in "real life" situations.

The capabilities of the PIC Development Board were tested by programming the as-supplied PIC using some of the Flowcode Tutorials. It performed the job perfectly. When "compile to PIC" is clicked on from within Flowcode, a box appears telling the user the stage that has been reached and whether or not the process has been successful. There is also a "program indicator" l.e.d. which operates during the time the PIC is being programmed. Programming is under full computer control without manual intervention.

The board has a row of 13 l.e.d.s (to indicate the logic states when Port A/B pins are used as outputs) and pushbutton switches (to apply a logic state of 1 when they are used as inputs); a bank of four seven-segment l.e.d. indicators and a two-line 16-character liquid crystal display (see photograph), with an associated contrast potentiometer. Also, there is a choice available between a crystal and on-board *RC* circuit (as set by a switch) to control the clock speed.

Students often like to run things very slowly (say, at 1Hz) to see the effect of each step in the program (which was available in Flowcode during simulation). For this, the *RC* mode of operation is used. An on-board potentiometer may be used to alter the time period of the RC circuit and hence the clock speed, in conjunction with a "fast/slow" selector switch.

In addition, the board has a 40-way expansion bus suitable for an IDC cable link. There are also connectors for an audio output (for tone generation), for digital and analogue external sensors and port inputs/outputs. A manual Reset switch is also present.

IN AND OUT

While learning Flowcode, many users will rarely remove the existing PIC from its socket. However, when programming PICs for use in your own circuits, if devices are inserted and removed too many times, this could cause excessive wear and tear to the socket. If you need to repeatedly remove and replace the PIC, you could use zero-insertion force (ZIF) sockets "piggy-back" style in the existing holders.

For home use, the on-board sockets will probably be satisfactory or you could use further standard turned-pin units inserted in the PIC sockets that are most used. This would be a cheaper alternative to using ZIF sockets. The new ones would then receive the wear and would be easily replaced.

CHECK IT OUT

As supplied, the PIC is ready-loaded with a test program. This checks for correct operation on delivery and takes the form of a simple "Knight Rider" effect (flashing the l.e.d.s from left to right then back again). If this is successful, the board is working correctly.

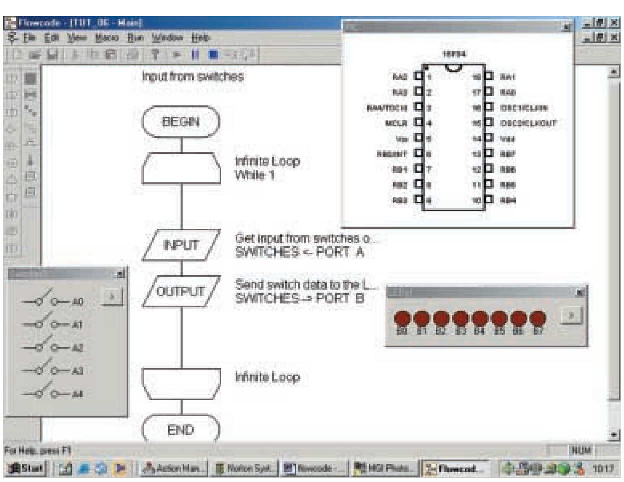
Some users will wish to study PICs for the needs of further education or industry. Others will want to work at home for self-interest and to develop their own programs. The materials are therefore made available in a student/home version; a single user institution version, a 10-user licence and a site licence. The student/home version does not have the burglar alarm and buggy simulations and this is reflected in the lower price. For many users, this will not matter.

Flowcode is an excellent concept. Those using it can concentrate on simulating a practical task without having to learn complex programming techniques. This and the PIC Development Board will be of great interest to the independent hobbyist as well as those involved with education and industrial training.

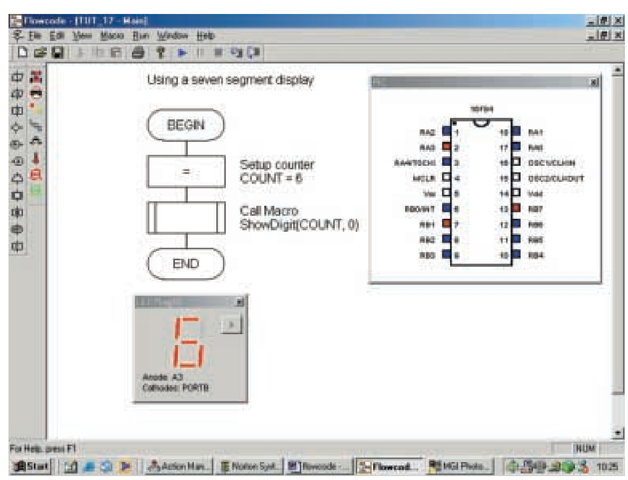
You can purchase *Flowcode for PICmicro* and the *PIC Development Board* from the *EPE Electronics CD-ROMs* pages in this issue – see page 677 for prices and ordering information.

SUPPORT

Technical support may be found at **www.matrixmultimedia.co.uk**. The web site will contain Frequently Asked Questions, and any updates for Flowcode that may be available from time to time. Support is also available via email at: **support@matrixmultimedia.co.uk**. It is also available by phone (but *not* for the student/home version). □



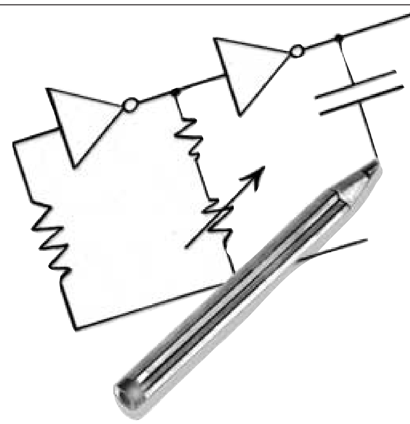
Using switches and the infinite loop.



Tutorial operating a 7-segment display by using a macro.

Special Feature

LOGIC GATE INVERTER OSCILLATORS



GEORGE HYLTON

Part One

A compendium of practical oscillator circuits for the creative experimenter, all based on inverting logic gates.

CMOS inverters can be usefully configured as oscillators. For sinewave generation it is usual to specify unbuffered inverters, whilst for other waveforms it may be more convenient to use the buffered kind. Many CMOS NAND and NOR gates can be connected so as to also behave as inverters, and thus as oscillators.

The aim of this article is to explain how inverter oscillators work and to give some simple design pointers.

CMOS INVERTER

The essentials of a typical single-stage CMOS inverter are shown in Fig.1. The heart of the circuit is formed around the two series-connected enhancement mode MOSFETs, TR1 and TR2, *p*-channel and *n*-channel respectively.

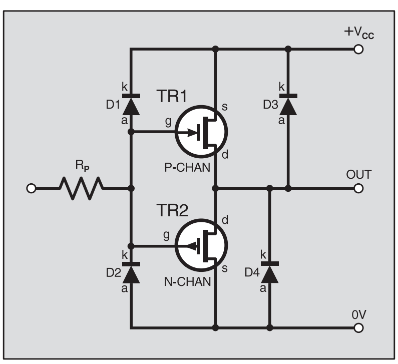


Fig.1. The essentials of a typical CMOS inverter, internal circuitry.

The source (s) of TR1 is connected to the positive supply line (V_{CC}). TR2's source is connected to the earthy (0V) side of the supply. The two drains (d) are connected together, as are the two gates (g). The whole configuration forms a complementary push-pull amplifier.

When used with digital signals, a sufficiently large positive input voltage turns TR2 on and TR1 off. The output is then low. An input voltage close to 0V takes the output high. It is unsafe to take the input more negative than about –0·5V as this can lead to damage of the chip.

At the input of this circuit is a protective resistance, R_P (typically about 200 ohms), and (usually) two gate protection diodes, D1 and D2. An excessive input voltage turns on one of the diodes and R_P then limits the current. There may also be two more protection diodes (D3 and D4) at the output. This stage, when used on its own, is known as an *unbuffered* inverter.

BUFFERING

In a *buffered* inverter, two more stages like this are added. The three-fold inversion gives the effect of a single inverter of much higher gain. The slope of the central portion of the input/output curve (Fig.2) is much steeper than a single inversion stage would produce. A digital input signal of high level makes the working point switch from P1 to P3, with a transition from P3 to P1 for a low level signal.

There is a price to pay for this steeper operation. If a slowly changing input is applied, a point may be reached where all three inversion stages are biased to working points such as that at P2. The overall gain is then very high and stray feedback can make the circuit jitter or oscillate.

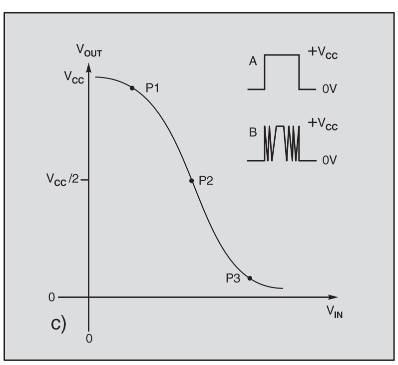


Fig.2. Input/output voltage curve for the circuit in Fig.1. For oscillators, P2 represents a typical working point. Ideally, output pulses should be as shown in waveform A*, but when buffered inverters are used they can have jitter, as illustrated in waveform* B.

Also, random voltage variations (noise) mixed up with the input can make the circuit turn on and off rapidly, giving an output like that at waveform *B* instead of the wanted one at waveform *A*.

This is why single-stage (unbuffered) inverters are preferred for sine wave oscillators, where the input is not a repetitive series of high/low pulses, but a smoothly changing waveform and where, in order to set up the inverter, it is biased to a working point in the region of P2.

DIODE CONDUCTION

Diodes D1 and D2 are not meant to conduct during normal operation. However, they may do so in oscillator circuits, with undesirable effects on the frequency. Fig.3 shows a common square wave oscillator circuit configuration known by various names, such as *astable, relaxation oscillator* and *multivibrator*.

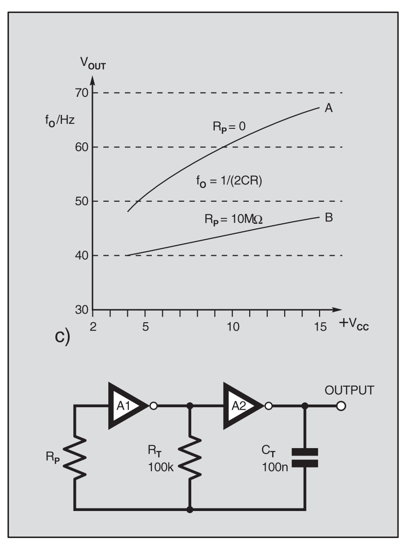


Fig.3. A two-inverter oscillator, showing the effect of V_{CC} on f_o, with and without swamping resistance R_P. Note that the frequency with Rp present is lower than the 50Hz obtained from the formula (see text).

Graph curve A shows the effect on frequency of changing the supply voltage V_{CC}. Part of the change in frequency is the result of protection diode conduction. The effect can be reduced by connecting a large extra protection resistance R_P in series with the input at A1. Curve B shows the change produced by increasing R_P to 10 megohms.

The extent to which a swamping resistance like R_P improves stability, or frequency accuracy, depends on how much bigger it is than the normal timing resistance, R_T. Note, however, that diode conduction is not the only influence on frequency stability. The output resistances of Al and A2, which are effectively in series with R_T and C_T respectively also affect timing, and they change with V_{CC}.

It is also necessary to be aware that increasing the value of R_p will reduce the oscillation frequency. This is due to the CR constant of this resistor in conjunction with the inverter's input capacitance affecting the circuit's principal time constant, determined by R_T and C_T.

Frequency can be adjusted by changing C_T or R_T. This resistance also sets up the d.c. conditions; with C_T disconnected (no oscillation) negative feedback from A1 output to input via R_T sets the working point to about that at P2 in Fig.2.

FREQUENCY DETERMINATION

A capacitor C charging from a d.c. voltage source through a resistance R acquires a charge voltage which builds up, at first rapidly, and then ever more slowly as the charge accumulates. Theoretically, C takes for ever to charge right up to the source voltage.

However, the charge reaches 63 per cent of the source voltage after a time of C × R seconds, known as the *time constant* CR, where C is in farads and R is in ohms. More conveniently, C can be in microfarads and R in megohms. Thus a capacitor of 1μF charged through 1MΩ becomes charged to 63 per cent of the applied voltage after one second.

In relaxation oscillators, such as that shown in Fig.3, the circuit changes state abruptly when the charge on C reaches the A1 inverter's critical threshold level, at about point P2 in Fig.2. At this point, the inverter whose output has been high switches to give a low output, and vice versa.

Capacitor C then discharges and when its voltage has decreased below the critical level, the circuit resets to its original state, and so on. If the charging and discharging threshold voltages are equal and the resistance is constant, the circuit generates rectangular waves with half cycles of equal duration, i.e. square waves.

In Fig.3, the time constant CR is 0·01 second (0·1MΩ × 0·1μF). Consequently, the charge and discharge periods each take 0·01 seconds, therefore one complete cycle takes 0·02 seconds. Using the period to frequency conversion formula f_o = 1/2CR, the frequency is thus 1/(2 × 0·01) = 50Hz.

It should be noted, though, that CR may also be affected by other stray R and C values within the circuit. As stated earlier, it can also be affected by differences in supply voltage, and by the value of R_P.

However, as an approximation the formula can be used to determine the likely frequency to be produced. It can also be re-arranged so that for a given frequency, the required values for *C* and *R* can be calculated.

Thus if *R* is known, to find the value of *C* required for frequency f_o, the formula is rearranged to become:

$C = 1/(2 \times f_o \times R)$

To find *R* when *C* is known, it becomes:

$R = 1/(2 \times f_o \times C)$

If the product *R*×*C* is megohms times microfarads the frequency is in Hertz. You can increase the units of *R* to 10M and correspondingly reduce those of *C* to 0·1uF (100nF) and still get f_o in Hz. In other words, if the units of *R* increase then those of *C* decrease by the same factor to get the same units of f_o. You can get f_o in kilohertz by having *R* in kilohms and *C* in microfarads or with *R* in megohms and *C* in nanofards.

You should also be aware that the actual values for the components used as *C* and *R* are subject to manufacturing tolerances. To adjust the oscillator frequency to that actually required, a variable resistor (i.e. potentiometer) can be inserted as in Fig.4.

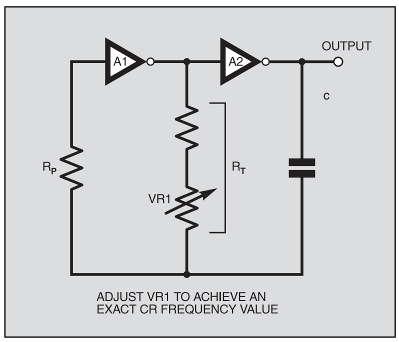


Fig.4. Frequency adjustment is provided by VR1. The ratio of maximum to minimum frequency can exceed 10 in low-frequency oscillators where C and VR1 are large. Frequency adjustment has little effect on the mark-space ratio.

MARK-SPACE RATIO

We have assumed in the foregoing discussion that the oscillator output is a square wave whose peak-to-peak voltage is close to V_{CC}. Because of differences between the MOSFETs manufactured into the CMOS inverter, the positive-going half-cycles may have slightly different durations to those of the negative-going half-cycles. They are said to have a different *mark-space* ratio.

If necessary, the mark-space ratio can be equalised with the aid of an adjustment circuit, such as that in Fig.5. In this case CR is calculated as *C* × *(R1 + (VR1/2))*, although the presence of D1 and D2 will modify the ratio, typically reducing the frequency due to the charge/discharge voltage having been reduced by about 0·7V.

A reasonable rule of thumb formula is shown in Fig.5.

To provide a wide spread for the mark-space ratio, the value of R1 should be kept small in relation to the value of VR1.

VOLTAGE RATINGS

Standard CMOS inverters, such as the 4069 hex inverter, can be used with V_{CC} up to 15V (18V for some manufacturers). Modern high speed "equivalents", such as the 74HC04, are restricted to a maximum V_{CC} of 6V. They may also draw more current when biased for oscillator use.

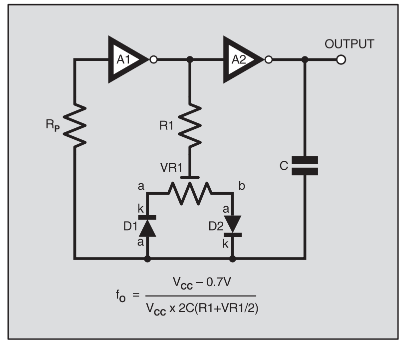


Fig.5. Mark-space adjustment is provided by VR1. When D1 conducts the effective resistance is R1 plus section a of VR1. When D2 conducts it is R1 plus VR1 section b. Thus the charge and discharge of C can be adjusted differentially. If a wide range of control is needed R1 can approach zero ohms.

SCHMITT INVERTERS

As illustrated in Fig.2, jitter can occur when a "normal" inverter's input voltage is at around the P2 level. To inhibit the jitter possible with slowly-changing inputs, CMOS inverters having a "snap" action, and known as Schmitt trigger inverters, can be used.

With these a slowly rising input voltage has no effect until an upper critical (threshold) value is reached. Then the high output flips abruptly to the low condition. If the input is then reduced slightly the output remains low.

Not until the input is lowered by a fairly substantial amount, to below the lower threshold level, does the output flip back to the high state. This backlash (hysteresis) prevents the output from jittering when there is noise mixed up with the input signal.

Schmitt trigger inverters can cope with signals arriving via long cables whose capacitance slows the rate of rise or fall of

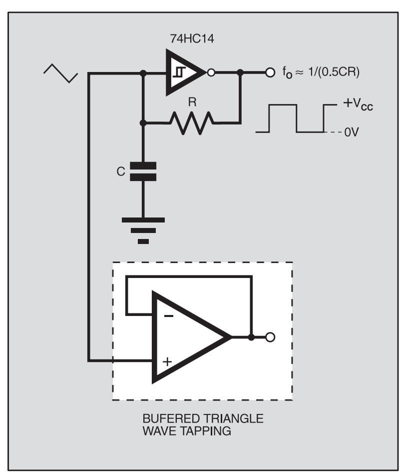


Fig.6. A Schmitt trigger inverter square wave oscillator which uses the minimum of components.

a pulse and which may pick up noise or interference.

Buffered Schmitt devices such as the 74HC14 hex inverter make good oscillators whose output waveform is very close to a square wave (Fig.6). The slight difference in the mark-space ratio which may be obtained is dependent upon the Schmitt trigger's precise upper and lower threshold levels.

The only external components needed are a resistor and a capacitor. These act as a kind of integrator which turns the square wave at the output into a triangular wave at the input. This has a lower amplitude (typically about 1V peak-to-peak for a 5V supply) than the square wave and is too small to turn on the protection diodes, consequently no swamping resistance is needed.

In a typical Schmitt inverter with V_{CC} = 5V the circuit changes state when the input voltage rises to about +3V or falls to about +2V. Since the d.c. average voltage on *C* is 2·5V ($V_{CC}/2$) changes in input voltage of 0·5V are all that is needed to flip the circuit from one state to the other.

The difference between the two critical threshold voltages is called the hysteresis voltage. For the 74HC14 inverter this is typically quoted on data sheets as 0·5V for V_{CC} = 2V, 0·8V for V_{CC} = 4·5V and 0·95V for V_{CC} = 6V.

Oscillation frequency is determined by how long it takes for these changes of input voltage to occur after a switch of output from high to low, or low to high. Since the required changes are only around one fifth of V_{CC} the time to produce them is relatively smaller than with the oscillators discussed so far.

The result is that the frequency is much higher than might be expected from the basic RC time constant. It is roughly 2/RC, but this is only an approximation since it is also affected by the supply voltage and the resulting hysteresis thresholds.

The triangle waveform at the junction of C and R can be tapped by using an op.amp buffer, as shown in the dotted box of Fig.6.

It is also possible to vary the mark-space ratio of the oscillator by using the diode and potentiometer configuration shown in Fig.5. This also has the effect of changing the triangle waveform to a rising or falling ramp (sawtooth).

SAWTOOTH OSCILLATOR

Another method of yielding sawtooth and pulse waveforms is shown in Fig.7, in which C is discharged via transistor TR1 as soon as the output of A2 goes high. The discharge of C causes the output of A2 to go low again, turning off TR1, whereupon C starts to charge up again and the process is repeated.

The discharge of C is very rapid and, almost immediate, but during the discharge of C there is a very short negative-going pulse at A1 output and a corresponding positive-going pulse at A2 output. The waveform at C is effectively a rising ramp.

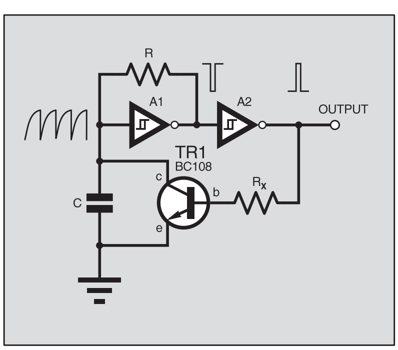


Fig.7. Sawtooth oscillator created by rapidly discharging C via TR1.

EQUALISATION

The sawtooth amplitude is about $V_{CC}/2$ and the rising of its slope is not linear. Linearity can be improved by substituting a constant current source for *R*. This can be made easier by taking advantage of the fact that the circuit still works if the top end of *R* is connected to $+V_{CC}$ instead of A1 output, as shown in Fig.8.

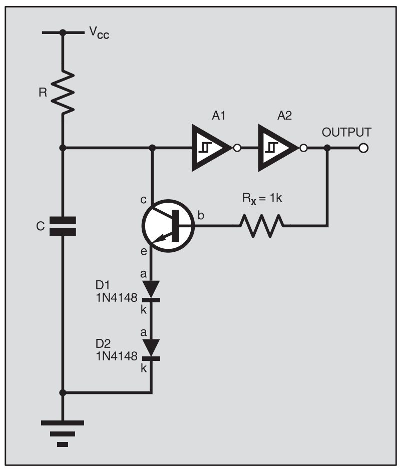


Fig.8. Linearising a sawtooth waveform.

There is, however, another problem. The frequency of the sawtooth is only about half that of the original triangular wave. The frequency can be increased by preventing C from discharging completely through TR1. With less recharging to be done the cycle speeds up.

In Fig.8 the speeding up is done by connecting two diodes in the emitter (e) of TR1. These make TR1 turn off before C is fully discharged. The inclusion of resistor Rx (of 1kΩ, say) prevents damaging current flow from A2 output through the base-emitter path of TR1.

With V_{CC} at +5V the sawtooth frequency will typically be about the same as the original triangle wave frequency and the two amplitudes will also be similar. Linearity is improved, too.

SINEWAVE OSCILLATORS

Oscillators can usually be considered as amplifiers with positive feedback. The feedback increases gain and if there is enough of it, the gain becomes infinite. Then any noise at the input is amplified by as much as the circuit will allow. In practice this means that the amplitude builds up until the system overloads. This reduces gain and stops any further increase.

In a sine wave oscillator, the positive feedback is channeled from output to input through some sort of filter which permits the greatest feedback at one particular frequency. This is the oscillation frequency.

PHASE REVERSAL

Since, in an inverter, a positive input voltage results in a negative output voltage an inverter should not oscillate if feedback is taken directly from output to input. Such feedback is negative and reduces gain.

Most CMOS sine wave oscillators do incorporate feedback from output to input, but only at d.c. The feedback's job is to set the working point on the linear part of the input/output curve and so establish the right starting conditions.

To permit a.c. oscillation, some arrangement must be incorporated to create a second phase reversal at the oscillation frequency. The two successive inversions (positive to negative, negative to positive) make feedback positive at the oscillation frequency.

One way of providing a second phase inversion is to pass signals through a second inverter (but note that this will not work with Schmitt inverters). This entails a risk, though: if feedback occurs at d.c. the working point may be de-stabilised. The result (latchup) leaves all the inverters either hard on or hard off (high or low), preventing a.c. oscillation. Also, if the overall feedback is over a wide band of frequencies, the circuit may oscillate at an unintended frequency.

Ways of avoiding these dangers will be covered later. For the present, let's look at other methods of obtaining a second phase inversion.

One method is to use a transformer. If the inverter output is applied to a primary winding, the secondary winding yields a copy, scaled up or down in voltage according to the turns ratio. The secondary winding is electrically isolated from the primary.

To make an oscillator, we choose the end of the transformer secondary winding which provides a voltage having the opposite polarity to the inverter's output voltage. This gives the required second inversion.

PRACTICAL SINEWAVES

A practical version, shown in Fig.9, incorporates a feedback adjuster, VR1, which can be set to control the strength of oscillation. In general, a setting which is just sufficient to ensure reliable oscillation gives the best waveform.

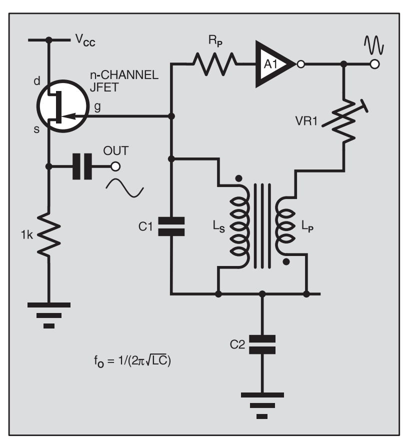


Fig.9 Using a transformer to produce phase inversion.

The frequency is determined by capacitor C1 and winding L_s. Capacitor C2 merely provides a bypass (decoupling) capacitance, and its presence ensures that there is d.c. negative feedback to stabilize the operating conditions.

A pure sine wave appears across L_s/C1. A distorted (peaks flattened) waveform appears at the inverter output but it can be made almost sinusoidal by careful setting of VR1.

The turns ratio depends on both the transconductance (g) of the inverter and the dynamic resistance (R_d) of the LC combination. The effect of the transformer is to reduce the impedance seen looking into the coupling winding from the inverter output to R_d/N^2, where N is the ratio of the turns on L_s to the turns on the coupling winding.

To design an oscillator, first assume VR1 = 0 then calculate the turns ratio which will just allow oscillation. For this N = (g × R_d). In this type of oscillator, the working point will be on the linear part of the characteristic, i.e. P2. Both f.e.t.s are on and g is the sum of their transconductances.

To take an example, if g = 3ms and R_d = 100k, N is 3/1000 × 100,000 = 300. To allow for adjustment and device spreads a lower turns ratio is chosen. The best value of VR1 is best found by experiment but is usually a few times the output resistance of the inverter; try a 100k preset.

The correct setting of VR1 should give reliable oscillation in the face of any likely supply-voltage variations. When set up correctly the level of signal at the input is low enough to ensure that the protection diodes never conduct. Hence R_p is not needed. This is important when frequency stability must be maximised because both R_p and input capacitance are temperature-dependent.

AMPLITUDE LIMITS

In any oscillator the amplitude increases until something stops it. In CMOS oscillators the limiting mechanism is peak flattening as the signals become large enough to be affected by the nonlinearity of the transfer characteristic. If VR1 is low enough to allow strong oscillation the output approaches a square wave.

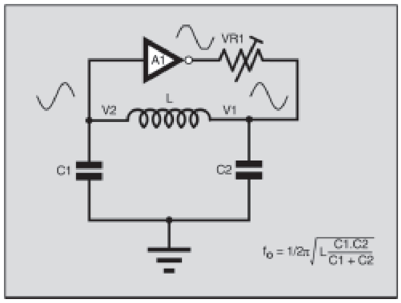


Fig.10 Colpitts oscillator. Phase inversion at the oscillating frequency is created by the pi-network C1, L, C2.

If VR1 is set for "just oscillating" the output is a sine wave except for slight peak crushing. The waveform across the LC itself can still be a good sinewave even when the output is crushed because the harmonics produced by crushing are attenuated by the LC circuit. With symmetrical crushing the main harmonic is the third and this is well away from the peak of the LC resonance curve.

When VR1 is set for strong oscillation the peak-to-peak output approaches V_{CC}. The level across the LC is normally much lower. The signal across the coupling winding is a good sine wave but only one Nth of the amplitude at the LC. To extract the full LC signal without upsetting circuit operation calls for a buffer, such as the f.e.t. follower in Fig.9.

COLPITTS OSCILLATOR

Transformers are often inconvenient. Designers may prefer to use a simple inductor without a secondary winding or tappings. In this case the required second inversion can be performed by the tuning components themselves.

In the usual arrangement shown in Fig.10, the two capacitances C1 and C2, together with inductance L, form a pi-network. This inverts the voltage at one specific frequency, that at which the reactance of L is the same as the reactance of C1 and C2 in series.

Oscillation may well be violent and the waveform poorly shaped. Adding a feedback-control resistance, VR1, provides a "throttle" control to adjust the oscillation level. Then the waveform at the inverter output is peak-clipped but good sine waves are obtainable across the capacitors. Because of the network phase inversion, waveform voltages V1 and V2 are in antiphase. If C1 = C2 (the usual case), the amplitudes of V1 and V2 are equal, but opposite.

This oscillator is a version of a classical one, the Colpitts oscillator. It is easy to get it oscillating. The requirement is that the inverter should produce a gain of over one when driving the impedance looking into the pi-network.

With C1 = C2, this impedance is a quarter of the dynamic resistance of the tuning circuit at the oscillation frequency. In most practical cases, this impedance is more than high enough and VR1 is needed to limit amplitude and ensure good waveforms. The value of VR1 is not critical. Even if the resistance is considerably less than the maximum possible, the waveforms can still be good.

At radio frequencies, the Colpitts circuit can be tuned by a two-gang variable capacitor in place of C1 and C2, with the rotor earthed. A tuning range (ratio of maximum to minimum frequency) in excess of three is usually obtainable. The range is limited by the practical tuning capacitors available, where $f_{max}/f_{min} = \sqrt{C_{max}/C_{min}}$ = about $\sqrt{10}$ in a circuit with typical stray capacitance.

To be concluded next month.

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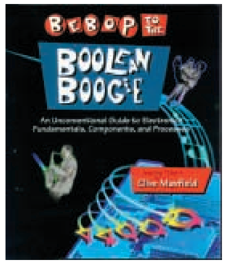

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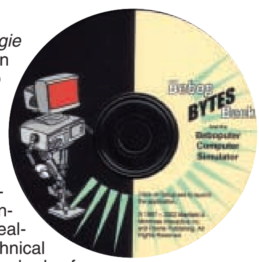

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Audio and Music

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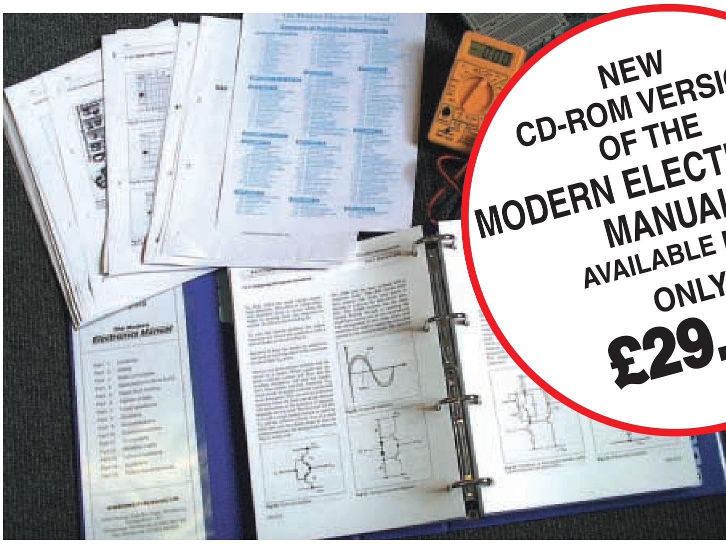

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USA & Canada	£28 each	£39 each
Far East & Australasia	£35 each	£43 each
Rest of World	£28 each	£52 each

Please allow four *working* days for UK delivery.
NOTE: Surface mail can take over 10 weeks to some parts of the world. Each ESM weighs about 4kg when packed.

mem-cd